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Embryological Studies in the Leguminosae. VIII. Acacia auriculaeformis A. Cunn., Adenanthera pavonina Linn., Calliandra hematocephala Hassk., and Calliandra grandiflora Benth.[1]

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In the previous seven papers, the author has given an account of the embryology of *Leucaena glauca* (1949), *Mimosa hamata* (1951a), *Pithecolobium saman* (1951b), *Neptunia triquetra* (1952), *Prosopis spicigera* and *Desmanthus virgatus* (1953, 1957), and *Dichrostachys cinerea* and *Parkia biglandulosa* (1954a, b), all belonging to the Mimosaceae. The present paper deals with four more plants of the Mimosaceae, viz. *Acacia auriculaeformis*, *Adenanthera pavonina*, *Calliandra hematocephala*, and *Calliandra grandiflora*. With respect to the last two plants, it has been observed that their embryology is almost identical.

MATERIALS AND METHODS

Material of *Acacia auriculaeformis* and *Adenanthera pavonina* was collected at the compound of the Law College and Maharajbagh Gardens, Nagpur and that of *Calliandra hematocephala* at the Indian Botanic Garden, Sibpur, Calcutta. Material of *Calliandra grandiflora* was supplied by Professor R. C. Lacy of Patna. It was fixed in formalin-acetic-alcohol and Randolph's modification of Navaschin's fluid (Johansen, 1940). As the wall of the fruits of *Acacia auriculaeformis* and *Calliandra* species is very hard, the portions of young fruits and older seeds, whose testa is very hard, were treated with a 10% solution of potassium hydroxide for 12 hours for softening of the pericarp and the testa before dehydration to facilitate cutting of sections.

At times, it was found that during the process of dehydration, sections of portions of fruits on slides were lost. This was due to hardness of the sections and the difficulty with which they adhered to the slide though Haupt's adhesive (Johansen, 1940) was used. In order to overcome this difficulty and to salvage all the sections, the author devised the following method.

[1]Abstract published in Bull. Bot. Soc. Univ. Saugar, 6: 51–52, 1953–54.

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After drying of the paraffin ribbon on it, the slide was dipped in a 1% aqueous solution of safranin or Ehrlich's haematoxylin (Johansen, 1940), for 5 minutes in the former or 10–15 minutes in the latter. It was then washed in a staining jar by changing distilled water 3 or 4 times. It was destained in acid water (4–5 drops of concentrated HC1 in 100 C.C. of distilled water) for 1–5 minutes depending upon the intensity of the stain. It was again washed in a jar by changing tap water 4 or 5 times, the slide being allowed to remain undisturbed in the jar. The slide was then kept for drying. After drying, it was treated with xylol to dissolve paraffin and again washed in xylol. The sections were finally mounted in canada balsam. The whole procedure including staining and mounting required only 40–50 minutes.

The results were quite satisfactory and the author wishes to recommend this method in those cases where urgency is required or when sections are likely to be lost during the usual procedure of staining.

Sections were cut from 6–15 μ and stained in iron-alum haematoxylin or Ehrlich's haematoxylin (Johansen, 1940). For pollen preparations, methyl green-glycerin jelly and aniline oil-gentian violet methods (Wodehouse, 1935) were employed.

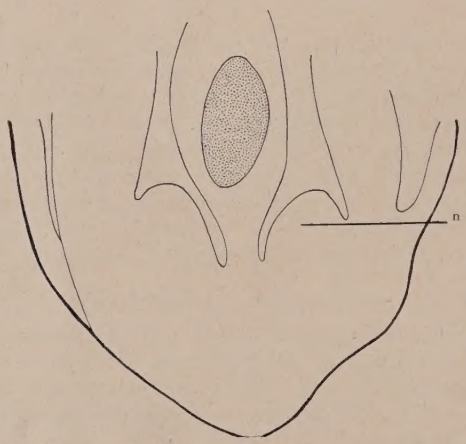


FIG. 1. L.S. part of flower of *Calliandra grandiflora* showing nectary, *n* at the base. × 25.

It has been observed that structures like narrow tubular haustoria can hardly be studied satisfactorily from microtome sections. It is for this reason that Kausik (1938) and later Rau (1950a) followed the development of endosperm in Proteaceae and Leguminosae, respectively, from microdissections also. The author dissected the young seeds previously treated with 10% potassium hydroxide for 24 hours (Johri, 1952), under the stereoscopic microscope. As the seeds were very small, the needles employed for syringes were found to be very useful while dissecting. The dissected endosperms were stained with Zirkle's acetocarmine (Johansen, 1940). This method has the advantage that in one operation, it performs fixing, staining and mounting.

THE INFLORESCENCE AND THE FLOWER

Acacia auriculaeformis, a native of tropical Australia is an introduced tree with smooth bark, sometimes taken for *Eucalyptus* because of the presence of laterally compressed falcate and oblong phyllodes which look very much like leaves of *Eucalyptus*. Flowers are small, yellow in color and are aggregated in slender axillary spikes. Anthers are crested with a gland. The floral formula is K(5), C(5), A ∞, G*1*.

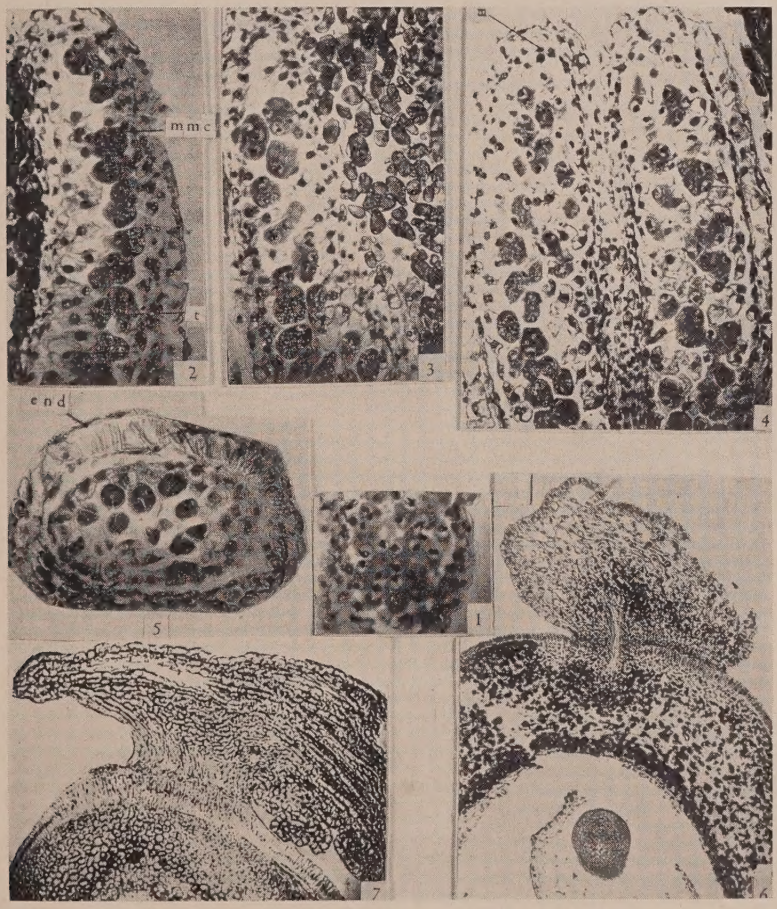
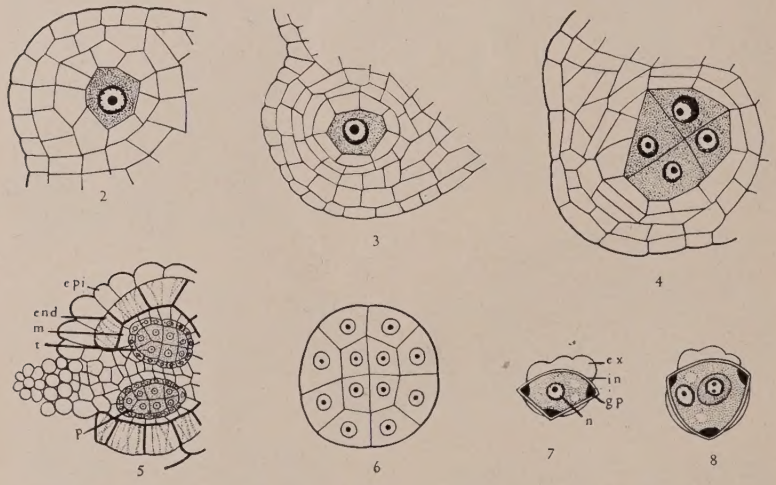


PLATE 1. FIGS. 1–7. *Adenanthera pavonina*—FIG. 1. L.S. part of anther showing packed microspore mother-cells. FIG. 2. Same, showing beginning of separation of groups of microspore mother-cells and tapetal cells which have lost contact with each other. *mmc*, group of microspore mother-cells; *t*, tapetal cell. FIG. 3. Same, showing migration of tapetal cells between groups of microspore mother-cells. FIG. 4. Same, showing scattered groups of microspore mother-cells due to wandering of tapetal cells among them. *m*, middle layers. FIG. 5. T.S. of mature anther showing several pollinia and endothecium, *end* with fibrous thickenings. FIG. 6. L.S. of micropylar part of seed of *Acacia auriculaeformis* showing funicular swelling and massive proembryo. FIG. 7. L.S. micropylar part of seed of *Adenanthera pavonina* showing growth in thickness on free part of funiculus. FIGS. 1–5, ×60 and FIGS. 6, 7, ×9.

Adenanthera pavonina is a handsome tall tree with rough dark colored bark. The inflorescence is a short peduncled spiciform raceme consisting of yellow fragrant flowers which are at first white in color. They slowly change to greenish yellow as they advance in age. Anthers are crested with a deciduous gland. The floral formula is K(5), C(5), A10, G*1*.

Calliandra hematocephala and *Calliandra grandiflora* are shrubs which look remarkably beautiful when in full blossom with their large bright crimson bottle-brush like flowers. The inflorescence in *Calliandra hematocephala* is an axillary globose head. In *Calliandra grandiflora*, the heads form terminal panicles. There is a nectary at the base of the flower (Fig. 1). The floral formula is K(5), C(5), A∞, G*1*.

The floral parts arise in acropetal succession and are cyclic in their arrangement.

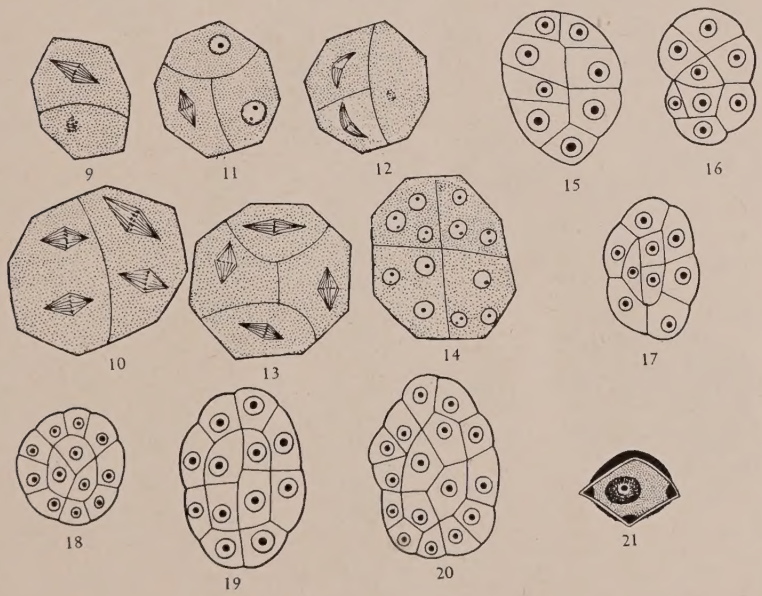


FIGS. 2–8. *Acacia auriculaeformis*—FIG. 2. T.S. lobe of anther showing a microspore mother-cell and two layers of parietal tissue. FIG. 3. Same, showing a microspore mother-cell and 4 layers of parietal tissue. FIG. 4. Same, showing 4 microspore mother-cells. FIG. 5. T.S. part of mature anther showing epidermis, *epi*, endothecium, *end*, with its thickened cells, middle layer, *m*, tapetum, *t* and pollinium, *p*. FIG. 6 Surface view of 16-celled pollinium showing 8 peripheral grains and a group of 4 central grains (other group being superposed, is not seen). FIG. 7. Individual pollen-grain showing exine, *ex*, intine, *in*, 3 germ pores, *gp* and nucleus, *n*. FIG 8. Individual bi-celled pollen-grain at the time of shedding. FIGS. 2–4, 6, ×500; FIG. 5, ×325 and FIGS. 7, 8.×800.

MICROSPOROGENESIS

The anther which is at first circular in outline becomes four lobed as usual. In *Acacia auriculaeformis* and *Calliandra* species, the archesporium differentiates as a single hypodermal cell which by its activity forms the parietal tissue (Figs. 2–4, 22–24). In *Adenanthera pavonina*, the archesporium is rather late in differentiation and is multicellular. The sporogenous cells can only be distinguished after formation of one or two layers of the parietal tissue.

The outermost layer of the parietal tissue is the endothecium. Its cells become enlarged and acquire characteristic fibrous thickenings when the anther becomes mature (Figs. 5, 26, and Pl. I, Fig. 5) as in all investigated species of the Mimosaceae. Ultimately, it is the only layer that persists, the rest being used up during sporogenesis. There are one or two middle layers (Figs. 3, 5, 24 and Pl. I, Fig. 4). The innermost layer is the tapetum. It is of the secretory type and its cells remain uninucleate throughout (Figs. 5, 24) as in all investigated species of the Mimosaceae. A feature of extraordinary and remarkable interest was observed with respect to the behavior of tapetal cells in *Adenathera pavonina*. When microspore mother-cells are to undergo meiosis, the tapetal cells begin to lose contact with each other. The cells which have thus become free from each other, migrate between groups of mother-cells which they begin to nourish (Pl. I, Figs. 2–4). Such a behavior of tapetal cells, as far as the author is aware, has not been recorded so far, and can be considered as intermediate between

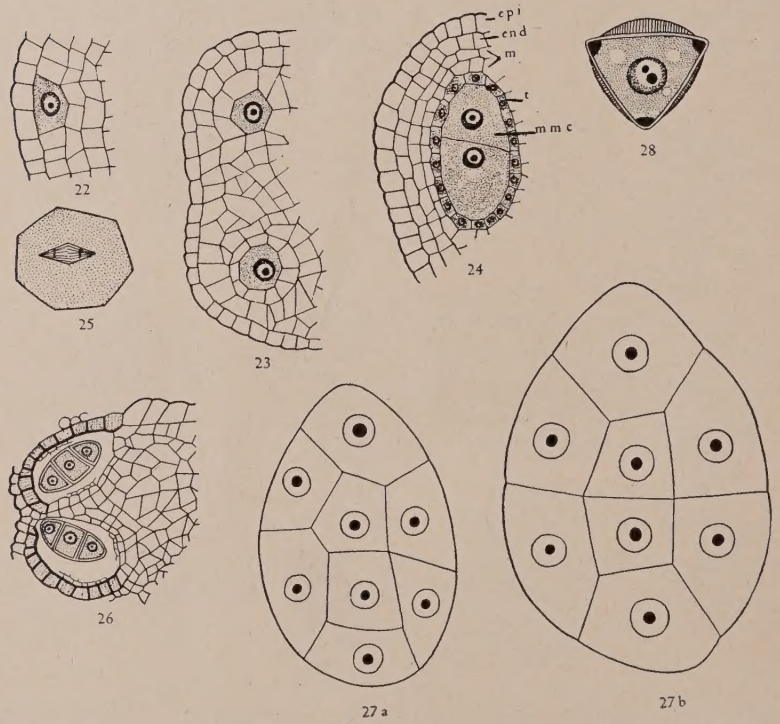


FIGS. 9–21. *Adenanthera pavonina*—FIG. 9. A group of 2 microscpore mother-cells during first meiotic division. FIG. 10. Same during second meiotic division. FIG. 11. A cell from a group of 3 microspore mother-cells undergoing first meiotic division. FIG. 12. All cells of a group of 3 microspore mother-cells undergoing first meiotic division. FIGS. 13, 14. A group of 4 microspore mother-cells undergoing first reduction division and just after second reduction division respectively. FIGS. 15, 16. Surface view of 8-celled pollinium formed by 2 isobilateral tetrads with different arrangement of grains. FIGS. 17, 18. Surface view of 12-celled pollinium made up of 3 tetrahedral (6 peripheral and 3 central grains are seen) and 3 isobilateral tetrads respectively. FIGS. 19–20. Surface view of 16-celled pollinium made up of 4 tetrahedral (8 peripheral grains and a group of 4 central grains are seen) and 3 isobilateral tetrads respectively. Fig. 21. Uninucleate pollen-grain. FIGS. 9–20, ×600 and FIG. 21, ×750.

the secretory and amoeboid types of the tapetum. A note (Dnyansagar, 1954c) on this has already been published separately. Eventually, the tapetal cells disappear when meiotic divisions are complete.

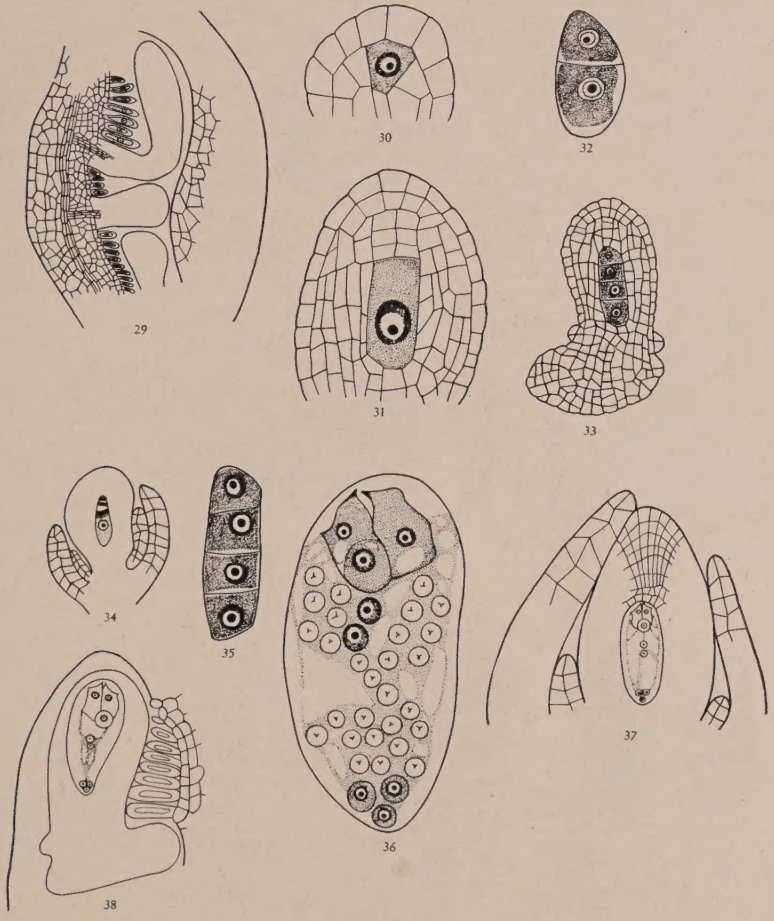
In *Acacia auriculaeformis*, 4 microspore mother-cells are produced per microsporangium (Fig. 4), while in *Calliandra* species, the number of microspore mother-cells formed per microsporangium is limited to 2 (Fig. 24). In *Albizzia lebbek* (Maheshwari, 1931) and *Acacia Baileyana* (Newman, 1933), 4 mother-cells and in *Acacia farnesiana* (Narasimhachar, 1948) 2–4 mother-cells per microsporangium have been reported.

After undergoing reduction divisions, the mother-cells produce 16 microspores in *Acacia auriculaeformis* and 8 in *Calliandra* species, which adhere to form a pollinium. Thus in these plants, the entire



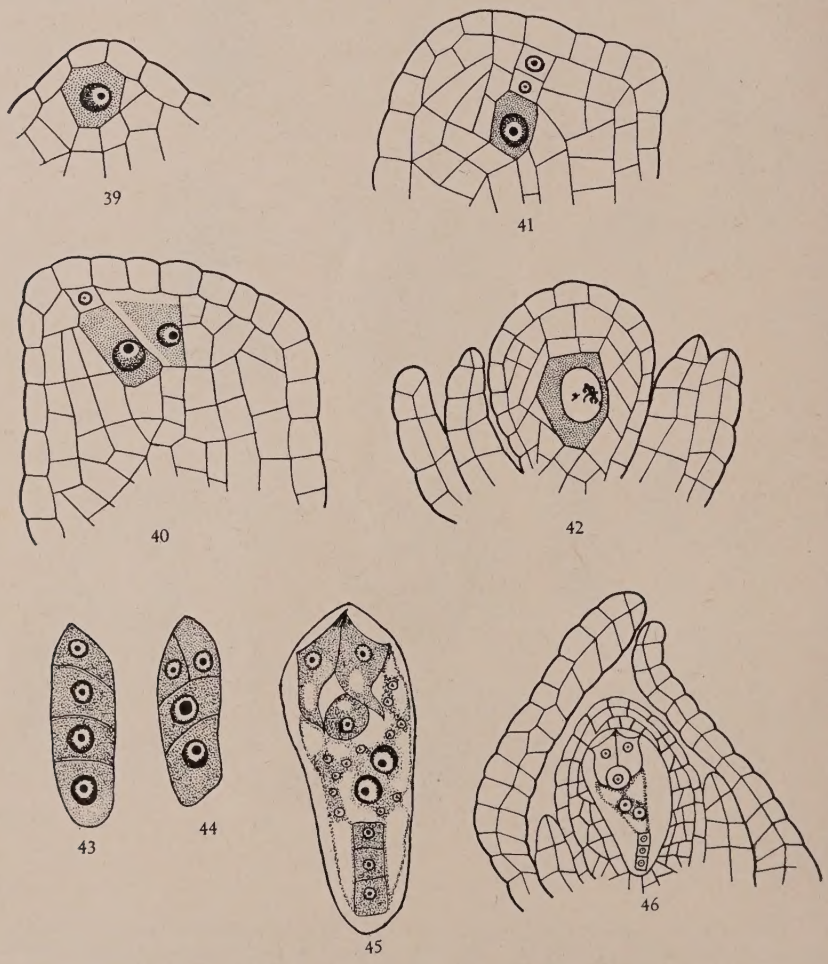
FIGS. 22–28. *Calliandra hematocephala*—FIG. 22. L.S. part of anther showing hypodermal archesporial cell. FIG. 23. T.S. part of anther through 2 lobes showing a microspore mother-cell and formation of parietal tissue in each lobe. FIG. 24. T.S. part of anther showing microspore mother-cells, *mmc*, tapetum, *t*, middle layers, *m*, endothecium, *end* and epidermis, *epi*. FIG. 25. A microspore mother-cell during first meiotic division. FIG. 26. T.S. part of mature anther showing a pollinium in each microsporangium, endothecium with its thickened cells and remains of middle layer and epidermis. FIG. 27a. Surface view of 8-celled pollinium. FIG. 27b. *Calliandra grandiflora*. Same as FIG. 27a. FIG. 28. Uninucleate pollen-grain of *Calliandra grandiflora*. FIGS. 22–25, 27a, b, ×217; FIG. 26, ×67 and FIG. 28, ×240.

mass of mother-cells in the microsporangium goes to contribute towards formation of a single pollinium (Figs. 5, 26) as in *Albizzia lebbek* (Maheshwari, 1931), *Acacia Baileyana* (Newman, 1933, 1934a, b), *Acacia farnesiana* (Narashimhachar, 1948) and *Pithecolobium saman* (Dnyansagar, 1951b).



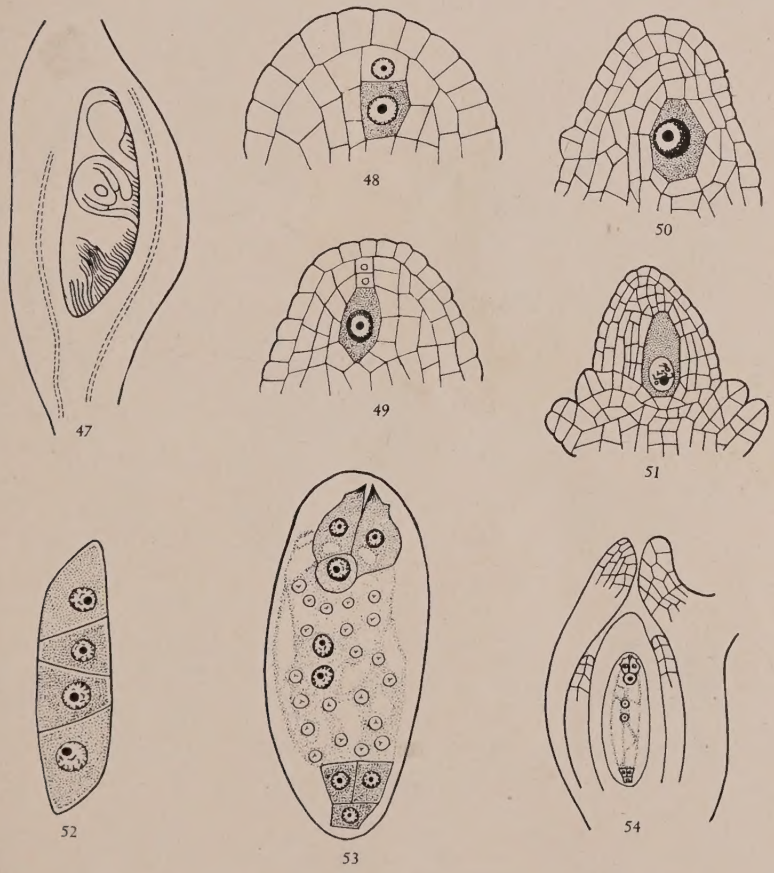
FIGS. 29–38. *Acacia auriculaeformis*—FIG. 29. L.S. part of ovary showing thickened cells lining placenta. FIG. 30. L.S. of nucellus showing single celled hypodermal archesporium. FIG. 31. Same, showing deep seated megaspore mother-cell, parietal tissue and formation of epidermal cap. FIG. 32. Megaspore mother-cell after first reduction division showing 2 cells. FIG. 33. L.S. of ovule showing linear tetrad of megaspores and primordia of integuments. FIG. 34. Same, at the tetrad stage of megaspores showing development of integuments. FIG. 35. Linear tetrad of megaspores. FIG. 36. Mature embryo-sac. FIG. 37. L.S. of ovule at the mature embryo-sac stage showing development of integuments and epidermal cap. FIG. 38. Same, showing naked nucellus, primordia of integuments and thickened cells from placenta. FIG. 29, ×45; FIGS. 30, 36, 37, ×320; FIGS. 31, 32, 35, ×200; FIGS. 33, 38, ×130 and FIG. 34, ×110.

In *Adenathera pavonina*, there are 4–6 vertical rows each consisting of several microspore mother-cells in each lobe of the anther. These are at first closely packed together and possess densely staining cytoplasm (Pl. 1, Fig. 1). They are polygonal in outline. On closer examination of this mass of mother-cells, it is found that it consists of groups of mother-cells, each group being of 2, 3 or 4 cells (Figs. 9, 10,



FIGS. 39–46. *Adenanthera pavonina*—FIG. 39. L.S. of nucellus showing single celled hypodermal archesporium. FIG. 40. Same showing 2 hypodermal cells, of which one on the left hand side has cut off a parietal cell. FIG. 41. Same, showing 2 parietal cells and megaspore mother-cell. FIG. 42. L.S. of ovule showing deep seated megaspore mother-cell, formation of parietal tissue and development of integuments. FIG. 43. Linear tetrad of megaspores. FIG. 44. T-shaped tetrad of megaspores. FIG. 45. Mature embryo-sac. FIG. 46. L.S. of ovule at the mature embryo-sac stage showing formation of micropyle by outer integument. FIGS. 39–41, 43–45, ×400; FIG. 42, ×300 and FIG. 46, ×200.

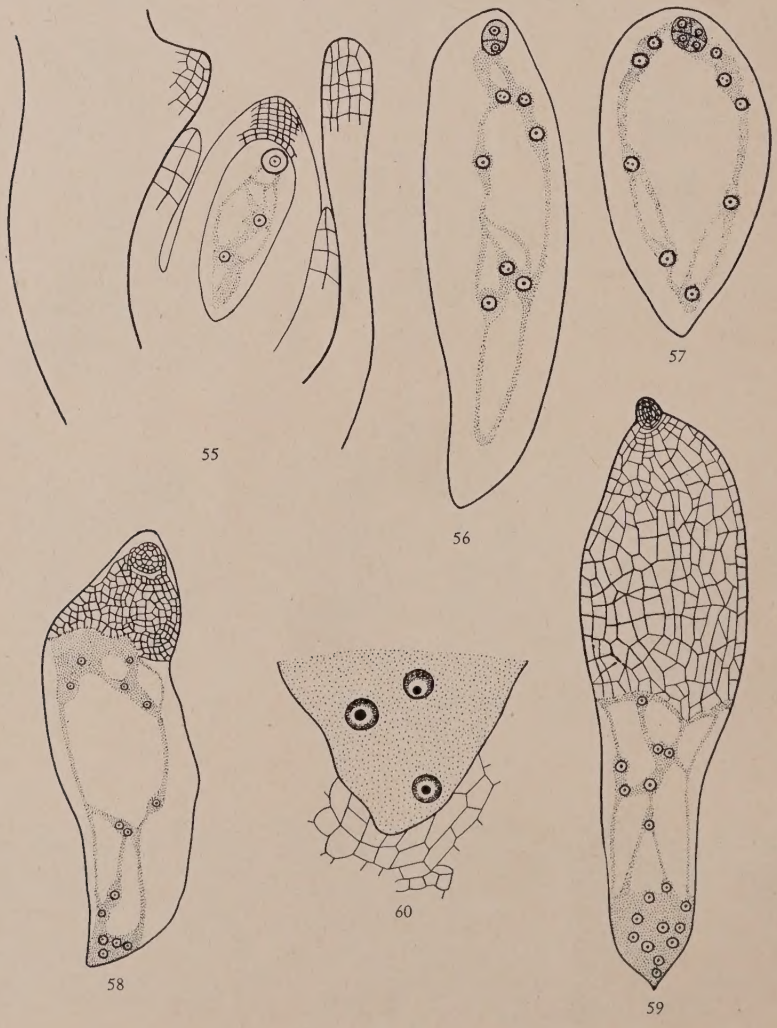
13 and Pl. 1, Fig. 4). It is interesting to note that each group consists of only those mother-cells which are formed as a result of the divisions of a single primary sporogenous cell. Later, these groups separate from each other as the tapetal cells begin to wander among them and eventually present a scattered arrangement (Pl. 1, Figs. 2–4). In *Dichrostachys cinerea* (Dnyansagar, 1954a), the mother-cells become arranged in groups of 2–4 in vertical rows. The mother-cells in each group then undergo two reduction divisions (Figs. 9–14) to give rise

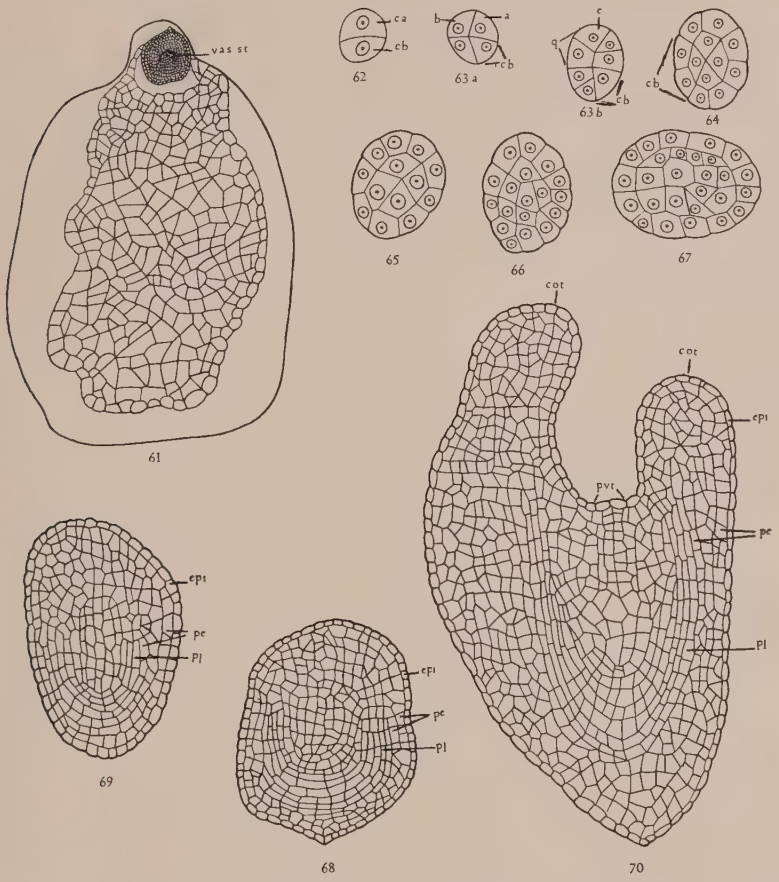


FIGS. 47–50, 53, 54. *Calliandra hematocephala;* FIGS. 51, 52, *Calliandra grandiflora.*—FIG. 47. L.S. part of ovary showing thickened cells lining placenta and vascular strands. FIG. 48. L.S. of nucellus showing megaspore mother-cell and parietal cell. FIG. 49. L.S. of nucellus showing megaspore mother-cell and 2 parietal cells. FIG. 50. Same, showing deep seated megaspore mother-cell and parietal tissue. FIG. 51. L.S. of ovule showing deep seated megaspore mother-cell, parietal tissue and primordia of integuments. FIG. 52. Linear tetrad of megaspores. FIG. 53. Mature embryo-sac. FIG. 54. L.S. of ovule at the embryo-sac stage showing formation of micropyle by outer integument. FIG. 47, ×17; FIGS. 48–51, 53, ×240; FIG. 52, ×333 and FIG. 54, ×53.

to a pollinium consisting of 8, 12 or 16 microspores, the number being dependent on the number of the mother-cells present in the group. Thus several pollinia are produced within each microsporangium (Pl. 1, Fig. 5). Formation of several compound pollen-grains or pollinia in a single sporangium has been reported in *Mimosa hamata* (Dnyansagar, 1951a), *Mimosa pudica* (Narasimhachar, 1951), *Dichrostachys cinerea* and *Parkia biglandulosa* (Dnyansagar, 1954a).

The reduction divisions (Figs. 9–14, 25) are simultaneous and cytokinesis takes place by furrowing as in all the investigated species of the Mimosaceae.





FIGS. 55–70. *Acacia auriculaeformis*—FIG. 55. L.S. of ovule at post-fertilization stage showing formation of micropyle, epidermal cap, endosperm nuclei and zygote. FIG. 56. Embryo-sac showing first division of oospore and several endosperm nuclei. FIG. 57. Embryo-sac showing 4-celled proembryo and endosperm nuclei arranged at periphery. FIG. 58. Same, showing spherical massive proembryo, cellular endosperm in micropylar region and free endosperm nuclei below. FIG. 59. Dissected embryo-sac showing spherical massive proembryo, cellular endosperm in micropylar region and chalazal endosperm haustorium. FIG. 60. Chalazal part of dissected embryo-sac enlarged. It shows endosperm haustorium in contact with nucellar tissue. FIG. 61. L.S. of seed showing advanced stage of embryo and cellular endosperm. FIGS. 62–70. Various stages showing development of embryo. Description in text. *cot*, cotyledon; *epi*, epidermis; *e*, epiphysis initial; *pe*, periblem; *pl*, plerome; *pvt*, stem apex. FIG. 55, ×217; FIGS. 56, 57, 60, ×183; 68–70, ×138; FIGS. 58. 59, ×37; FIG. 61, ×28 and FIGS. 62–67, ×300.

POLLINIA AND POLLEN-GRAINS

A mature pollinium of *Acacia auriculaeformis*, *Adenathera pavonina*, *Calliandra hematocephala*, and *Calliandra grandiflora* is 25–40 μ, 40–50 μ (16-celled), 25–30 μ (12-celled), 20–25 μ (4-celled), 60–90 μ and

80–130 μ in diameter, respectively. In *Acacia auriculaeformis*, the pollinium which is 16-celled is formed by 4 tetrahedral groups each occupying a quarter in a sphere (Fig. 6). In each quarter, there are 2 grains at the periphery which are conjoined and polyhedral. Two grains are at the center and are superposed. Thus the central group consists of 8 grains arranged in two superposed groups of 4 each and presents a square in outline having a convex face towards outside. A similar type of pollinium has been described in *Vachellia farnesiana* (when 16-celled), *Acacia* (Wodehouse, 1935), *Dichrostachys cinerea* (when 16-celled) and *Parkia biglandulosa* (Dnyansagar, 1954a).

Development of pollen-grains of *Acacia* has been studied by Rosanoff (1865) and Engler (1876). According to these authors, after two successive meiotic divisions in the microspore mother-cell, the four cells which are formed are separated by clearly defined walls and they tend to be all in the same plane and rectangular in arrangement. This is the reason why the pollinium in *Acacia* shows the squared arrangement. In *Calliandra* species, the pollinium is made up of 6 peripheral and 2 central grains (Figs. 27a, b). This arrangement shows that probably it is made up of 2 isobilateral tetrads.

In *Adenanthera pavonina*, the pollinium consists of 8, 12 or 16 cells (Figs. 15–20). In the 8-celled pollinium when formed by two tetrahedral tetrads, 4 grains are at the periphery and 4 in the center in 2 superposed groups of 2 each. When it is made up of 2 isobilateral tetrads, 6 grains are at the periphery and 2 in the center (Fig. 16) or there are 2 juxtaposed rows of 4 cells each (Fig. 15). The 8-celled pollinium formed by 2 isobilateral tetrads has also been reported in *Dichrostachys cinerea* (Dnyansagar, 1954a). The 12-celled pollinium formed by 3 isobilateral tetrads, consists of 6 cells at the periphery and 6 in the center arranged in 2 superposed groups of 3 each (Fig. 17), the latter representing a triangle in outline. When 3 isobilateral tetrads combine to form the 12-celled pollinium, there remain 9 cells at the periphery and 3 at the center (Fig. 18). The 16-celled pollinium formed by 4 tetrahedral tetrads (Fig. 19) shows the same arrangement as in the case of the pollinium of *Acacia*. When it is formed by 4 isobilateral tetrads, 12 cells become arranged at the periphery and 4 in the center (Fig. 20). Occasionally, a microspore mother-cell remains

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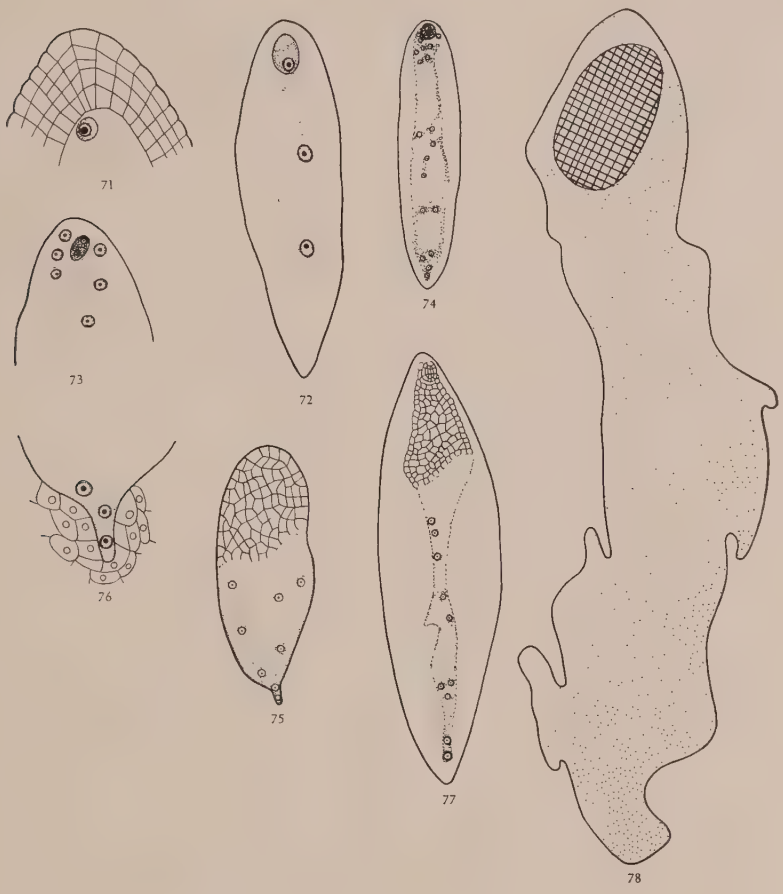
EXPLANATION OF FIGURES

FIGS. 71–87. *Adenanthera pavonina*—Fig. 71. Micropylar part of embryo-sac showing epidermal cap and zygote. FIG. 72. Embryo-sac showing 2 endosperm nuclei and zygote. FIG. 73. Micropylar part of embryo-sac showing first division of zygote and 6 endosperm nuclei. FIG. 74. Embryo-sac showing free nuclear endosperm and 4-celled proembryo. FIG. 75. Dissected endosperm showing cellular micropylar part and chalazal haustorium. Fig. 76. Chalazal part of embryo-sac showing endosperm haustorium in contact with nucellar tissue. Fig. 77. Embryo-sac showing spherical massive proembryo, formation of cellular endosperm in micropylar region and free endosperm nuclei below. FIG. 78. Advanced stage of embryo (cut through cotyledonary region) surrounded by endosperm which has become completely cellular. FIGS. 79–87. Various stages showing development of embryo. Description in text. *pco*, cotyledonary region proper. Other legends same as for FIGS. 62–70. FIGS. 71–73, ×110; 85–87, ×225; FIGS. 74, 75, 77, ×22; FIG. 76, ×130; FIG. 78, ×10 and FIGS. 79–84, ×600.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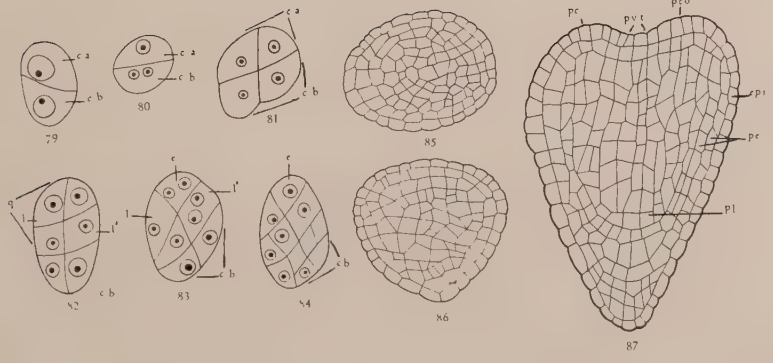
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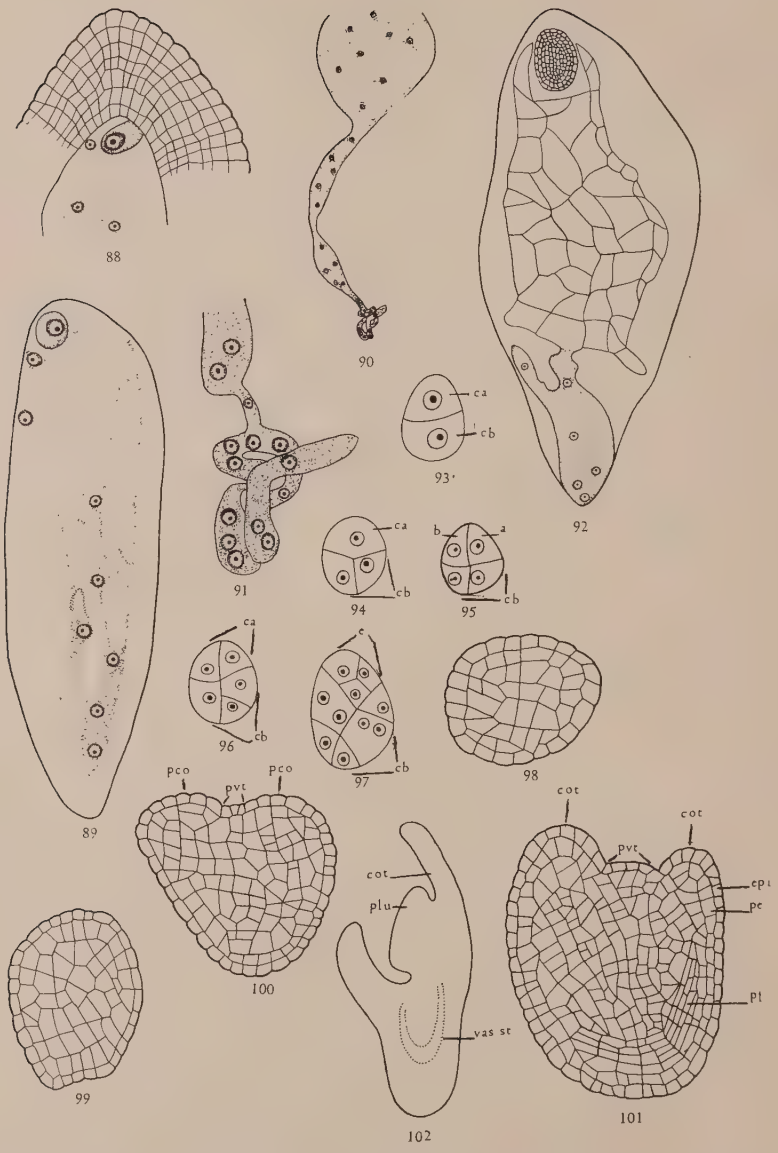
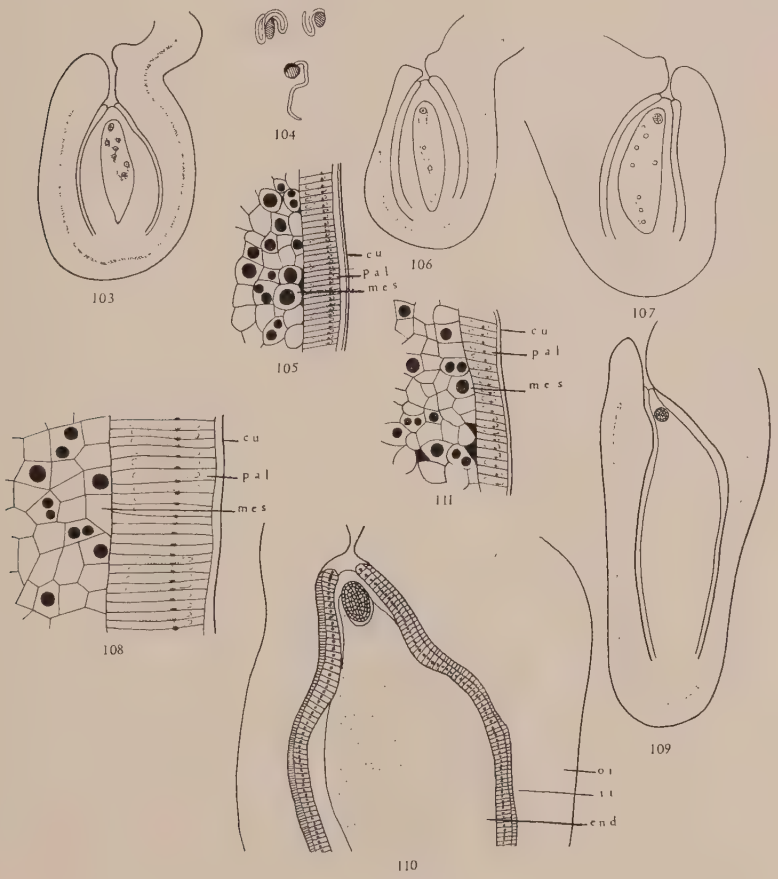


FIGS. 88–102. *Calliandra hematocephala*—FIG. 88. Micropylar part of embryo-sac showing epidermal cap, zygote and 3 endosperm nuclei. FIG. 89. Embryo-sac showing zygote and free nuclear endosperm. FIG. 90. Lower part of dissected endosperm showing twisted haustorium. FIG. 91. Same, showing twisted haustorium enlarged. FIG. 92. Embryo-sac showing massive proembryo, formation of cellular endosperm in micropylar part and free endosperm nuclei below. FIGS. 93–102. Various stages showing development of embryo. Description in text. *pco*, cotyledonary region proper; *plu*, plumule. Other legends same as for FIGS. 62–70 FIGS. 88, 89, 91, 98–102, ×110; FIGS. 90, 92, ×222 and FIGS. 93–97, ×240.

by itself and thus does not form part of a group. This consequently gives rise to a 4-celled compound grain.

In all species used in this study, pollinia are compact as the grains are firmly held together.

The individual grain of *Acacia auriculaeformis*, *Adenanthera*



FIGS. 103–111. *Acacia auriculaeformis*—FIG. 103. L.S. of ovule at the 2-celled stage of proembryo showing post-chalazal extension of vascular strand. FIG. 104. Mature seeds with funiculus. FIG. 105. L.S. part of seed-coat. *cu*, cuticle; *mes*, mesophyll; *pal*, palisade. FIGS. 106–108. *Adenanthera pavonina*—FIG. 106. L.S. of ovule at the undivided zygote stage showing post-chalazal extension of vascular strand up to half length of integuments. FIG. 107. Same, at the 4-celled proembryo stage showing post-chalazal extension of vascular strand almost up to micropyle. FIG. 108. L.S. part of seed-coat. Legends same as for FIG. 105. FIGS. 109–111. *Calliandra hematocephala*—FIG. 109. L.S. of ovule at the massive stage of proembryo showing post-chalazal extension of vascular strand. FIG. 110. L.S. of seed showing massive proembryo and persistent inner integument, *ii* with its tapetum like inner layer. *end*, endosperm; *oi*, outer integument. FIG. 111. L.S. part of seed-coat. Legends same as for FIG. 105. FIGS. 103, 106, 107, 110, ×28; FIG. 104, ×¼; FIGS. 105, 108, 111, ×138 and Fig. 109, ×12.

pavonina, *Calliandra hematocephala*, and *Calliandra grandiflora* is 7.5–10 μ, 9–13 μ, 30–50 μ and 35–50 μ in diameter, respectively. The exine on the exposed surface is thicker while on the inner sides, it is thin allowing the grain to be shaped suitably by pressure against neighboring cells. Each grain possesses 3 germ pores (Figs. 7, 21, 28).

The pollinia are shed as such and individual grains are bi-celled at the time of dehiscence of the anther (Fig. 8).

MEGASPOROGENESIS

The ovary is long, superior and monocarpellary with ovules developed in two alternating rows on the marginal placenta. It is stalked in *Acacia auriculaeformis* and *Calliandra* species.

After formation of the megaspore mother-cell, the placental region of the ovary becomes covered with thick walled cells in *Acacia auriculaeformis* and *Calliandra* species (Figs. 29, 38, 47). The appearance of such cells has been noted by Newman in *Acacia Baileyana* (1934b) and by the author in *Parkia biglandulosa* (1954a). Newman has interpreted these cells as unicellular hairs which "may in some young stage, stimulate integuments". The fact that these cells are larger than the placental cells and contain larger nuclei embedded in dense cytoplasm rather suggests nutritive function.

Ovules appear as small papillae from the carpellary margin at the stage when the microspore mother-cells are formed in the anther. The carpel has, at this stage, the form of a linear structure folded upwards along the mid-rib. This fact agrees with the classical interpretation of the foliar nature of the carpel. Such a condition has been seen by the author in all species of the Mimosaceae previously investigated by him. Newman (1933, 1934a, b) critically discussed the morphology of the carpel in *Acacia Baileyana* and supported the classical theory.

The young ovules which are at first orthotropous gradually assume anatropous form on coming close to the opposite wall of the ovarian cavity and subsequent acute curvature upward. This condition is common in a number of leguminous species of the Mimosaceae previously investigated. In *Acacia auriculaeformis*, however, the ovules remain amphitropous (Fig. 38) and it is only after fertilization that many of them become anatropous. A similar condition is found in *Acacia Baileyana* (Newman, 1933, 1934a, b).

The nucellus is very massive from the beginning, a feature which appears to be characteristic of the Mimosaceae.

Primordia of integuments arise from the base of the nucellus after differentiation of the archesporium in *Adenanthera pavonina* and *Calliandra* species (Figs. 42, 51), while in *Acacia auriculaeformis* they appear usually when the embryo-sac becomes mature (Fig. 38). Such belated appearance of integuments has been seen in *Acacia Baileyana* (Newman, 1934b) where they appear after fertilization. In two cases, however, it was seen that they developed at the stage when the linear tetrad of megaspores was formed (Fig. 33) and in one case, the outer integument had grown up to half the length of the nucellus (Fig. 34). Guignard (1881) described integuments in *Acacia* reaching the same level as the nucellar apex when the embryo-sac is at the mature stage.

According to Newman (1934b), Guignard may have examined carpels shortly after fertilization.

The inner integument develops first and the outer one soon follows. Both of them are bilayered in the beginning (Figs. 37, 42, 51). Subsequently the outer integument becomes several layered while the inner one remains bilayered throughout (Figs. 54, 55). The micropyle is formed by the outer integument alone (Figs. 46, 54, 103) as in *Albizzia lebbek* (Maheshwari, 1931), *Neptunia oleracea* (Singh and Shivapuri, 1935), *Leucaena glauca* (Dnyansagar, 1949), *Pithecolobium saman* (Dnyansagar, 1951b), *Mimosa pudica* (Narashimhachar, 1951), *Neptunia triquetra* (Dnyansagar, 1952), *Prosopis spicigera* and *Desmanthis virgatus* (Dnyansagar, 1953, 1957), and *Dichrostachys cinerea* (Dnyansagar, 1954a). In *Acacia Baileyana* (Newman, 1934a, b) and *Mimosa hamata* (Dnyansagar, 1951a), it is formed by both integuments, while in *Parkia biglandulosa* (Dnyansagar, 1954a) the inner integument forms the micropyle.

The archesporium is hypodermal and single celled (Figs. 30, 39). It cuts off a parietal cell by a periclinal wall (Figs. 41, 48). Fig. 49 shows the periclinal division of the primary parietal cell. In *Adenanthera pavonina*, two archesporial cells had developed in one case, one of which was observed to have cut off a parietal cell (Fig. 40). A multicellular archesporium has been reported in *Mimosa pudica* (Narashimhachar, 1951), *Prosopis spicigera* and *Desmanthus virgatus* (Dnyansagar, 1953, 1957) of the Mimosaceae, *Trifolium pratense* (Martin, 1914) and *Medicago sativa* (Martin, 1914 and Reeves, 1930) of the Papilionaceae. Several cases of more than one cell and even more than one embryo-sac have been reported by Newman in *Acacia Baileyana* (1934b) and two embryo-sacs in several species of *Acacia*. Newman, however, did not find any example in *Acacia Baileyana* of more than one tetrad in an ovule. He, therefore, concluded that the occasional occurrence of more than one functional spore may be due to development of more than one spore of a tetrad. It is interesting to note that in one case he observed two mother-cells in synapsis. But as there is no tissue between the mother-cells, he suggested the possibility of their arising by division from a primary sporogenous cell. Since a multicellular archesporium has occasionally been observed in some species of Mimosaceae, it is possible that these two mother-cells may have developed from two archesporial cells.

An extensive parietal tissue is formed as a result of activity of the parietal cell (Figs. 31, 33, 42, 50, 51). Such an extensive tissue has been seen in all previously investigated species of Caesalpiniaceae and Mimosaceae and therefore, seems to be a characteristic feature of these groups.

The megaspore mother-cell becomes deep seated due to formation of the extensive parietal tissue (Figs. 31, 42, 50). It then enlarges and, after undergoing two meiotic divisions, forms a tetrad of four cells. The first division as usual is transverse and gives rise to two dyad cells (Fig. 32). The second division is also transverse and results in a linear tetrad of megaspores (Figs. 35, 43, 52). In *Adenanthera pavonina*, a T-shaped tetrad was observed in one case (Fig. 44). A similar condition has been seen in *Leucaena glauca* (Dnyansagar, 1949),

Prosopis spicigera (Dnyansagar, 1953, 1957), and *Dichrostachys cinerea* (Dnyansagar, 1954a).

The chalazal megaspore functions and forms the embryo-sac as in *Albizzia lebbek* (Maheshwari, 1931), *Neptunia oleracea* (Singh and Shivapuri, 1935), *Acacia farnesiana* (Narashimhachar, 1948), *Leucaena glauca* (Dnyansagar, 1949), *Mimosa hamata* (Dnyansagar, 1951a), *Mimosa pudica* (Narasimhachar, 1951), *Pithecolobium saman* (Dnyansagar, 1951b), *Neptunia triquetra* (Dnyansagar, 1952), *Prosopis spicigera* and *Desmanthus virgatus* (Dnyansagar, 1953, 1957), *Dichrostachys cinerea* and *Parkia biglandulosa* (Dnyansagar, 1954a). In *Acacia Baileyana* (Newman, 1934b), it is either the chalazal or the distal megaspore that functions. According to Guignard (1881), most of the possible variations in the number of megaspores formed from a single mother-cell are found in the Leguminosae. These variations are (1) the mother-cell functioning as the spore, (2) formation of two spores from a mother-cell, (3) formation of 3 unequal spores from a mother-cell, (4) formation of 3 equal spores from one mother-cell and lastly (5) formation of 4 equal spores from one mother-cell. He listed the Caesalpiniaceae and Mimosaceae in the last two groups.

The embryo-sac enlarges by crushing the parietal tissue. It is then capped by the epidermal tissue developed by periclinal divisions of epidermal cells (Figs. 37, 46, 71, 88). At the time of fertilization, the sac comes in direct contact with the epidermal cap.

Starch-grains begin to appear in the sac when it is 8-nucleate (Figs. 36, 45, 53). Guignard (1881) reported their appearance in *Acacia* even at the megaspore mother-cell stage. Dahlgren (1939) and the author (1951a, b, 1952, 1953, 1954a) listed the species of Leguminosae in which starch-grains appear in the sac and the species used in this study represent further additions.

The mature embryo-sac is 8-nucleate and conforms to the Normal or Polygonum type (Figs. 36, 45, 53). When mature, it is broad at the micropylar end and narrow towards the chalazal end. The synergids are hooked and each has a filiform apparatus. The presence of hooked synergids has been reported in several species of Leguminosae. Dahlgren (1938) and the author (1951a, b, 1952, 1953, 1954a) reviewed the literature on hooked synergids in Leguminosae. The species used in the present study represent additions to the list.

The antipodals form definite cells as in all investigated species of Leguminosae.

ENDOSPERM

The endosperm follows the nuclear type of development. This type has been observed in all investigated species of Leguminosae. The primary endosperm nucleus divides before the first division of the zygote (Figs. 55, 72, 89). When the zygote undergoes the first division, several endosperm nuclei are already formed (Figs. 56, 73). At this time, the sac increases in size at the cost of the nucellar tissue and vacuoles appear here and there. The nuclei are at first peripheral in position (Fig. 57) but they soon accumulate in micropylar and chalazal parts of the sac (Fig. 74).

Wall-formation commences at the micropylar end when the embryo has become several celled and extends gradually toward the chalazel end (Figs. 58, 61, 77, 78, 92). The endosperm forms a collar around the embryo (Figs. 61, 77, 92).

At the chalazal end, the endosperm remains free nuclear even at the massive stage of the embryo. This part of the endosperm is tubular and comes in deep contact with the chalazal tissue (Figs. 58–60, 75, 76, 92). In *Adenanthera pavonina* (Figs. 75, 76) and *Calliandra hematocephala* (Figs. 90, 91), these tubular haustoria are very prominent and in the latter, the tubular process becomes coiled and twisted and is found lying compressed in the free space below the cellular zone. These tubular processes are seen clearly in whole mounts (Figs. 60, 75, 90). The method employed for dissecting out the endosperm has already been described under, "Materials and Methods". In *Grevillea robusta*, a member of the Proteaceae, Kausik (1938) described a coiled tubular coenocytic process of the endosperm and called it the vermiform appendage. Similar form of the appendage has been reported in *Cassia tora* (Rau, 1950a), *Cassia occidentalis*, *Cassia auriculata*, and *Cassia glauca* (Pantulu, 1951) of the Caesalpinaceae, *Crotalaria* (Rau, 1951a) and *Glycine javanica* (Rau, 1951c) of the Papilionaceae. A tubular process which is not twisted has been described by the author in *Prosopis spicigera* (1953, 1957), *Dichrostachys cinerea*, and *Parkia biglandulosa* (1954b) of the Mimosaceae.

In *Acacia auriculaeformis* and *Calliandra hematocephala*, no trace of the endosperm is left in the mature seed as it is completely resorbed by the developing embryo. In *Adenanthera pavonina*, however, a little trace is left at the chalazal end. Corner (1951), who has critically studied the structure of seeds of several species of Leguminosae, states that in the Adenantherae and Eumimosae tribes of the Mimosaceae, the seeds are albuminous with endosperm at least in the chalazal half of the seed. Pantulu (1951) reported that a thin layer of the endosperm persists around the embryo even in the mature seed of *Cassia occidentalis*.

EMBRYO

Acacia auriculaeformis (Figs. 62–70): The first division of the zygote is transverse resulting in formation of a terminal cell, *ca* and a basal cell, *cb* (Fig. 62). Both of these cells divide by vertically oblique walls and give rise to a globular tetrad (Fig. 63a) corresponding to the category B_1 of the Series B of the system of embryogenic classification of Souèges (1948a) and Souèges and Crété (1952). Thus cell *ca* forms two juxtaposed cells, *a* and *b*. At the third cell-generation, cell *a* divides by an oblique wall, the upper daughter cell lying at the summit, being the epiphysis initial, *e* (Fig. 63b). Cell *b* also divides and in this way, four quadrants, *q* are formed. At the fourth cell-generation, first initials of the epidermis are isolated toward the exterior. Afterwards, it becomes difficult to follow any regular sequence and identify actual limits of various zones due to irregularity of divisions which are mostly tangential and oblique. As the divisions are irregular, the cells of the epiphysis do not remain distinct for a long time. Ultimately, a massive globular proembryo is formed where there is no differentiation between the embryo proper and the suspensor (Figs. 65–67). Sub-

sequently, in due course, the cotyledonary portion and fundamental regions of the stem are differentiated from the terminal portion and the hypocotyledonary and root zones from the basal portion of the massive proembryo (Figs. 68–70).

Adenanthera pavonina (Figs. 79–87) and *Calliandra hematocephala* (Figs. 93–102): The general course of development of the embryo in these two plants is quite similar to that of *Acacia auriculaeformis*. In *Adenanthera pavonina*, the cells derived from the quadrants show two well defined tiers, *1* and *1'* (Figs. 82, 83).

Guignard (1881) worked out the embryogeny of various species of *Acacia*, *Mimosa pudica*, and *Mimosa denhartii*. He states that due to small size of the cells and irregularity of the divisions, it becomes extremely difficult and almost impossible to determine the origin of parts that constitute the embryo from the two primary cells of the two-celled proembryo. The appearance of irregular divisions after the second cell-generation and subsequent formation of an undifferentiated massive type of the proembryo has been reported by Newman (1934b) in *Acacia Baileyana*, by Narasimhachar in *Acacia farnesiana* (1948) and *Mimosa pudica* (1951), and by the author in *Leucaena glauca* (1949), *Mimosa hamata* (1951a), *Pithecolobium saman* (1951b, *Neptunia triquetra* (1952), and *Prosopis spicigera* and *Desmanthus virgatus* (1953, 1957). In *Dichrostachys cinerea* and *Parkia biglandulosa* (1954b), after the fourth cell-generation the divisions become irregular and a massive pear-shaped or globular proembryo is formed where there is no differentiation between the embryo proper and the suspensor. According to Johansen (1950), the embryogeny of *Acacia Baileyana* follows the Trifolium Variation, Onagrad Type save that a suspensor is not formed.

Souèges has worked out the embryogeny of *Genista tinctoria* (1947a), *Ulex europaeus* (1947b), *Sarothamnus scoparius* (1947c), *Thermopsis fabacea* (1948b), *Dorycnium rectum* (1949), and *Tetragonolobus siliquosus* (1950), all belonging to the Papilionaceae. Although these plants follow the embryonomic type of *Trifolium minus* (Souèges, 1929), demarcation of the suspensor from the embryo is less distinct. Moreover, the stages corresponding to the segmentation of quadrants beneath the epiphysis and differentiation of two layers, *ph* and *h* which give rise to the hypocotyledonary and hypophyseal regions, respectively, are less irregular. Souèges and Crété (1952) have put this type of embryogeny as shown by these plants under the Megarchtype VI, *b* of Series B of the First Period where the first tetrad is of B_1 type and *Trifolium minus* under *a* of the same series. A close study of the development of the embryo in the above plants, viz. *Genista tinctoria*, *Ulex europaeus*, *Sarothamnus scoparius*, *Thermopsis fabacea*, *Dorycnium rectum*, and *Tetragonolobus siliquosus*, indicates that the embryogeny of the species used in this study is most nearly like theirs.

SEED

A single vascular strand lies in the region of the chalaza prior to fertilization, but there occurs the post-chalazal extension of the strand in the outer integument when the divisions in the zygote are taking

place. At the massive stage of the embryo, the extended part of the strand reaches almost up to the micropyle (Figs. 103, 106, 107, 109). Corner (1951) stated that with the exception of certain species of *Bauhinia*, the post-chalazal extension of the strand occurs in seeds of Caesalpiniaceae and Mimosaceae. Such a condition has been described by Netolitzky in a few Papilionaceae, by Rau (1950b) in *Cassia tora* of the Caesalpiniaceae and by the author in *Leucaena glauca, Mimosa hamata, Pithecolobium saman, Neptunia triquetra* (1952), *Prosopis spicigera* and *Desmanthus virgatus* (1953, 1957), *Dichrostachys cinerea* and *Parkia biglandulosa* (1954b) of the Mimosaceae.

In *Acacia auriculaeformis*, growth in thickness appears on the free part of the funiculus parallel with the seed after fertilization. As a result of this growth, a cushion of parenchymatous tissue is formed which lies against the side at the micropylar end of the seed (Pl. I, Fig. 6). This tissue is often referred to as an aril which is regarded by some as a third integument. Such a funicular swelling has been described by Newman (1934b) in *Acacia Baileyana*. The part of the funiculus away from the aril becomes extremely elongated and remains in the form of a coiled thread closely applied to one side of the seed parallel to its longitudinal axis (Fig. 104). When the pod dehisces, seeds with yellow aril and long funiculus hang out of the carpel walls.

According to Corner (1949), only 18 genera of the Leguminosae have arillate seeds. He includes 2 genera (*Acacia* and *Pithecolobium*) in the Mimosoideae, 14 in the Caesalpinioideae, 1 in the Papilionatae and 1 in the Swartzioideae. He states that every arillate genus in the Leguminosae shows in different species all stages of reduction culminating in complete loss of the aril. The case of *Acacia auriculaeformis* represents reduction in aril. Corner says that seeds in *Adenanthera* are red with persistent funicle but no aril. The author has seen during the development of the seed of *Adenanthera pavonina*, the appearance of growth in thickness on the free part of the funiculus at the massive stage of the embryo (Pl. I, Fig. 7). Later Corner (1951), however, stated that "in *Adenanthera pavonina*, one may note the limited origin of the aril as an indication of morphogenic centres in the developing seed". According to Sporne (1949), the possession of an aril is a primitive feature of the angiospermous seed. This view has been supported by Corner (1949) while Pijl (1952) considers the aril to be of no phylogenetic value.

Brown pigments, probably of tannin, begin to appear in cells of the outer and inner integuments and in the chalazal region of the nucellus after fertilization in *Acacia auriculaeformis* and *Calliandra hematocephala* and from the megaspore stage onward in *Adenanthera pavonina*.

The inner integument disappears completely in *Acacia auriculaeformis* and *Adenanthera pavonina* but in *Calliandra hematocephala* it is persistent even in the mature seed. At the massive stage of the proembryo, cells of the inner layer of the inner integument elongate in the transverse direction and their cytoplasm becomes dense in *Calliandra hematocephala* (Fig. 110). As the embryo-sac enlarges, the surrounding nucellar tissue is crushed and it then comes in direct contact with the inner layer of the inner integument on the lateral sides. This suggests the possibility that the integumentary cells of

the inner layer assume a nutritive role. Such a tapetum like inner layer was observed by Rau (1951b) in *Vigna catjung* (1951b) and *Clitoria ternatea* (1951c) of the Papilionaceae.

The structure of the mature seed of the Mimosaceae was described in detail by Corner (1951). The testa in the species used in this study shows the same structure (Figs. 105, 108, 111) described by Corner and hence need not be described here.

SUMMARY

1. *Acacia auriculaeformis*, a native of Australia has small yellow flowers aggregated in slender axillary spikes. In *Adenanthera pavonina*, the inflorescence is a short peduncled spiciform raceme consisting of yellow fragrant flowers. In *Calliandra hematocephala* and *Calliandra grandiflora*, large bright crimson bottle-brush like flowers are borne in axillary globose heads and terminal panicles, respectively.

2. Floral parts arise in acropetal succession and are cyclic in their arrangement.

3. The parietal tissue consists of endothecium, one or two middle layers, and a tapetal layer. The tapetum is of the secretory type and its cells remain uninucleate. In *Adenanthera pavonina*, the tapetal cells become separate from each other and wander between sporogenous cells with their intact walls. It is suggested that this type of tapetum is intermediate between the secretory and amoeboid types and serves to link them.

4. In *Acacia auriculaeformis* and *Calliandra* species the archesporium in the microsporangium is a single hypodermal cell. Four microspore mother-cells in *Acacia auriculaeformis* and two in *Calliandra* species are formed in each lobe of the anther which after 2 meiotic divisions give rise to a pollinium of 16 and 8 microspores, respectively. In *Adenanthera pavonina*, the archesporium in the anther differentiates rather late and is multicellular. Several microspore mother-cells arranged in 4–6 vertical rows are formed in each microsporangium. These mother-cells are arranged in groups of 2, 3, and 4. These groups become scattered due to wandering of tapetal cells and ultimately form pollinia consisting of 8, 12 or 16 microspores, the number being dependent on the number of cells present in the group.

5. Pollinia are shed as such and individual pollen-grains are bicelled at the time of shedding.

6. The parietal region of the ovary in *Acacia auriculaeformis* and *Calliandra* species becomes covered with thick walled cells.

7. Ovules are anatropous and primordia of integuments appear after differentiation of the archesporium in the nucellus in *Adenanthera pavonina* and *Calliandra* species. In *Acacia auriculaeformis*, ovules are amphitropous and some of them become anatropous after fertilization. Integuments usually appear when the sac becomes mature.

The micropyle is formed by the outer integument alone.

8. Megasporogenesis occurs in the normal way. A single hypodermal archesporial cell differentiates in the massive nucellus and cuts off a primary parietal cell which later on forms an extensive tissue. The epidermal cells undergo several divisions to form an epidermal cap.

In *Adenanthera pavonina*, two hypodermal archesporial cells were observed in one case. A linear tetrad of megaspores is formed, the chalazal of which is functional. In *Adenanthera pavonina*, a T-shaped tetrad was also recorded in one case.

9. The embryo-sac conforms to the Normal or Polygonum type. The synergids are hooked and each has a filiform apparatus. The antipodals form definite cells. Starch-grains appear in the sac when it becomes 8-nucleate.

10. Endosperm follows the Nuclear type of development. The primary endosperm nucleus divides before the first division of the zygote. At the chalazal end, the endosperm remains free nuclear even at the massive stage of the embryo and is tubular. In *Adenanthera pavonina* and *Calliandra hematocephala*, the tubular haustorium is very prominent and in the latter becomes coiled and twisted.

11. Stages in the development of the embryo have been followed in detail and, in broad outlines, follow the Trifolium Variation of Onagrad type of Johansen except that a suspensor is not formed or the Megarchtype VIb of the Series B of the First Period of Souèges.

12. The post-chalazal extension of the vascular strand takes place in the outer integument up to the micropyle after fertilization. In *Acacia auriculaeformis*, the funiculus becomes extremely elongated. There is limited formation of the aril in *Acacia auriculaeformis* and *Adenanthera pavonina* at the micropylar end of the seed. The inner integument is persistent in the seed of *Calliandra hematocephala* and performs a nutritive function.

In conclusion, it may be stated that some of the outstanding features of embryological interest are (1) a tapetum intermediate between the secretory and amoeboid types in *Adenanthera pavonina*, (2) formation of many pollinia in each microsporangium, each developing from a group of 2–4 microspore mother-cells in *Adenanthera pavonina*, (3) endosperm haustorium on the chalazal side, (4) development of the rudimentary aril in *Acacia auriculaeformis* and *Adenanthera pavonina*, (5) persistence of the inner integument in the mature seed to function as the tapetum in *Calliandra hematocephala* and (6) presence of a small amount of endosperm in the chalazal region of the mature seed of *Adenanthera pavonina*.

These features along with other problems of controversial interest encountered in various species of Mimosaceae will be discussed in a separate paper.*

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A New Species of Psathyrella

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During two trips in search of hallucinogenic fungi in Mexico Singer and Guzmán, and later G. Guzmán alone, collected a striking new species of *Psathyrella* characterized by strongly ornamented spores and thus belonging in the group formerly often separated as a genus—*Lacrymaria* Pat. According to special studies on this group carried out earlier by A. H. Smith, this species is extremely close in general aspect as well as to a certain degree in colors and even in a number of important microscopical characters to *Psathyrella velutina* but differs in the very prominent ornamentation of the spores, the cheilocystidia which are less filamentose, and the fibrils on the cap which more closely resemble those of *P. echiniceps* in color and degree of development. The stipe reaches a greater length in the new species than in *P. velutina*.

The Indians of the Sierra Costera in Oaxaca, Mexico, report this as being hallucinogenic. This, if true, would introduce the first species outside *Psilocybe* sensu stricto and the few species of *Panaeolus*, *Copelandia*, *Conocybe*, reported earlier as proved or suspected to be hallucinogenic in Mexico. Nevertheless, in the case of the new *Psathyrella*, it should be kept in mind that the species as occurring in the Sierra Costera (our type collection) is somewhat similar to *Psilocybe zapotecorum*, a demonstrably hallucinogenic species, occurring in that part of Oaxaca. It seems reasonable to assume that a mistake in the identification of this species by the Zapotec indicating it as hallucinogenic is possible. Consequently, until actually tested in the laboratory or in the field, and proven to be active, we merely mention the information obtained in San Agustín de Loxicha.

In the Mazatec region around Huautla, the species is not considered hallucinogenic.

Psathyrella sepulchralis spec. nov.

Pileo fibrilloso-squamuloso, marginem versus longe fasciculato-fibrilloso, fibrillis atrobrunneis vel brunneis; lamellis griseolis, dein atropurpureo-brunneo-marmoratis, acie pallidis; stipite seape elongato usque ad 240 mm., squamuloso vel floccoso-squarroso vel reticulato e fibrillis eis pilei simillimis, ad apicem albido pruinato vel sericeo-fibrilloso e fibrillulis subtilibus appressis. Sporis nigris, sub microscopio 9.5–12.5 x 7.8–9.2 μ, verrucosis; basidiis tetrasporis, coprinoideis; pleurocystidiis fasciculatim dispositis, 40–50 x 9–14 μ; cheilocystidiis abundantibus, 38–70 x 8.5–10.5 μ; cellulis epicutis inflatis, fibulatis.

Pileus 20–90 mm. broad, broadly campanulate, surface fibrillose-squamulose, toward the margin with appressed fascicles of long dark brown or brown fibrils (reminding one of *P. echiniceps* (Atk.) Smith), ground color paler brown or orange brown, deeper on the disc, margin often beautifully appendiculate from the partial veil.

Lamellae grayish becoming dark purple brown to blackish and mottled, close, narrow to only moderately broad, edge pallid.

Stipe at first as in *P. velutina* in size and shape, but eventually often up to 260 mm. long, apex about 5 mm. broad and gradually slightly to distinctly enlarged downward and often reaching 9–10 mm. diameter at base, squamulose to floccose-squarrose or variously ornamented, often reticulate, with brown to dark brown fibrils similar to those of the pileus, ground color pallid or at any rate paler than in the pileus, apical region whitish, smooth and silky fibrillose from fine appressed fibrils.

FIG. 1. About ⅔ of natural size, fruiting bodies in fresh condition, type Phot. G. Guzmán Huerta.

Context whitish in pileus, brownish in stipe; odor farinaceous or lacking.

Spores in deposit black.

Spores 9.5–12.5–(13.5) x 7.8–9.2–(10.5) μ, broadly elliptic in face view, coarsely verrucose and with a hyaline bubble-like apical pore, blackish brown under the microscope in KOH when mature (but details of ornamentation best seen in immature spores); basidia 22.5–37.5 x 7.5–9.7 μ, 4-spored, hyaline to pale fuscous in KOH, coprinoid (some short-clavate, some ventricose at mid-portion and elongated above); pleurocystidia grouped in fascicles (the fascicles scattered),

40–50 x 9–14 μ, subcylindric to slightly ventricose in mid-portion, neck only slightly narrowed and apex broadly rounded, contents hyaline to pale fuscous in KOH; cheilocystidia abundant, 38–70 x 8.5–10.5 μ, hyaline to pale fuscous, elongate-clavate to slightly ventricose, the apical region ovoid to subcapitate; hymenophoral trama regular, the hyphae subparallel with pale fuscous walls in KOH; subhymenium ramose-irregular, fuscous in KOH; fibrils of the pileus of parallel hyphae with the walls 0.8–1 μ thick and colored ochraceous by a membranal pigment which also incrusts the surface; epicutis a layer of inflated cells several deep, the cells ± 25 x 20 μ; hyphae of the context in KOH hyaline to dingy ochraceous; clamp connections present.

Solitary on soil under herbaceous plants in a cemetery or near the margin of the forest, often with Chenopodiaceae and Malvaceae, fruiting in June and July, more rarely until September if the season remains moist. Mexico, Oaxaca, near San Agustín Loxicha, *G. Guzmán*, September 14, 1957, no. *SA-1140*, type (MICH), syntype (Herbarium of the Instituto Politécnico, Mexico, D.F.)—Huautla de Jimenez, *R. Singer & G. Guzmán*, July 11, 1957, no. *M 1520*, paratype (MICH).

Studies on the Wilt Disease of Cumin (Cuminum Cyminum L.) in Ajmer State, India

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The occurrence of wilt of Cumin (*Cuminum cyminum* L.) was first reported by Gaur (1949) in a popular account of this disease. Since then wilt has become a very common disease in this state and may be regarded as an epiphytotic. As we have studied this disease for several years, we now wish to summarize the results of our work.

IMPORTANCE OF THE CROP

The crop is cultivated for the sake of its fruits which are used as a spice in cookery and also have medicinal value. "The crop is said to be a native of Egypt though in India itself its cultivation is very old" (Aiyer 1944). In Ajmer the crop is grown about the end of October maturing in about 90 days. It is regarded as the most profitable cash crop and every year this State exports Cumin worth several lacs of rupees.

SYMPTOMS OF THE DISEASE

The infection was first observed before flowering in 8 to 10 weeks old crop. At the time of flowering, i.e., January and February, it was at its maximum, affecting 50% to 70% of the plants. The affected young plants showed sudden and outright wilting.

In the earlier stages the disease occurred in scattered patches as if excessive transpiration had taken place and the leaves had lost turgidity. It was followed by drooping of the whole plant which dried and got destroyed. In later stages the disease covered the whole field. The primary roots of the diseased plants were mostly devoid of laterals. The dried roots were found heavily infested with the exogenous mycelium which also showed sporulations.

Sections across the affected roots had a light brown color in the xylem vessels. The hyphae had been traced in the stem and the roots. The xylem vessels nearest to the center were severely affected. In some vessels microconidia and macroconidia were abundantly developed (Fig. 1). In advanced stage the tissue contained a net work of fungus filaments (Fig. 1).

ISOLATION OF THE FUNGUS

Some pieces of roots and stems of the diseased plants were thoroughly washed with water and treated with 0.01% mercuric chloride solution for 2 to 6 seconds and again washed with sterile water 2 to 3 times leaving no trace of mercuric chloride. The pieces were kept in moist chamber after cutting some of them longitudinally so that the central tissue may be exposed fully. Soon after 24 hours white cottony growth was found in each piece. A portion of the growth was transferred to a test tube containing oat meal agar and its growth was noted at intervals.

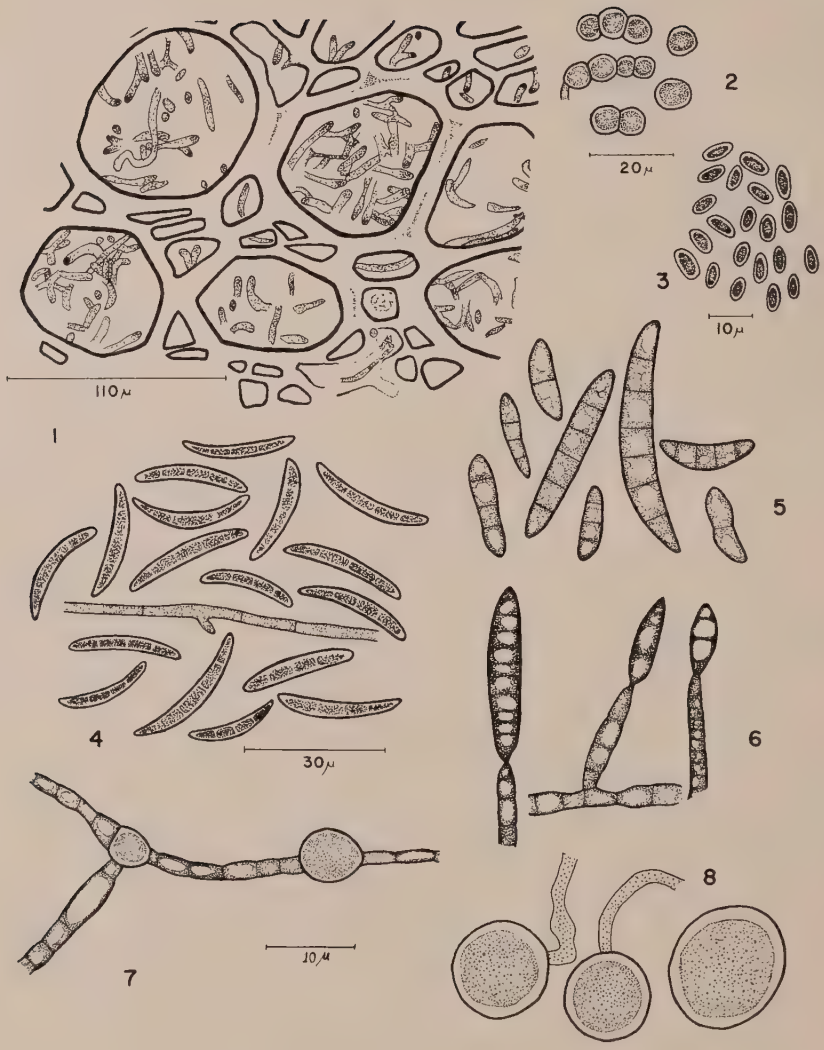

FIG. 1. Prescence of *Fusarium* sp. in the vessels of the roots of the badly affected plants.
FIG. 2. Chlamydospores in chain.
FIG. 3. Microconidia.
FIG. 4. Macroconidia (low magnification).
FIG. 5. Macroconidia (high magnification).
FIG. 6. Macroconidia attached to conidiophore.
FIG. 7. Intercalary chlamydospore.
FIG. 8. Mature chlamydospores (high magnification).

PATHOGENICITY TEST

The isolates obtained from the roots of the diseased plants on being cultured on oat meal agar developed only into cultures of *Fusarium* sp. and were then tested for their parasitism on the said host. Five earthen pots were filled with soil and sterilized at 15 lbs. pressure for 20 minutes. Later on in four of them (leaving the fifth as control) one month's old growth of the fungus in culture was added. Some seeds disinfected with mercuric chloride solution (0.01%) were sown in each pot. The results obtained from the above experiments have shown that the fungus isolated from the wilted plants can cause wilting of young seedlings of cumin by artificial inoculations. The results are shown in Table 1.

TABLE 1.—*Showing number of seedlings that appeared and number of seedings wilted in the soil artificially inoculated with the pathogen.*

S. No.	No. of experimental pots	No. of seedling appeared	No. of seedling wilted	% of wilted plants
1	Pot No. 1	25	18	72%
2	" " 2	19	13	68.9%
3	" " 3	22	16	72.7%
4	" " 4	26	20	76.9%
5	" " 5	18	0	00%

MORPHOLOGY OF THE FUNGUS

The morphological characters of the fungus were studied on oat meal agar. The white mycelium developed and covered the entire medium within 16 days. The cultures were kept at room temperature, i.e., 24° to 28° C. Microconidia, macroconidia, and chlamydospores were observed. The macroconidia were slightly curved, mostly 3 septate though the conidia with 2 or 4 septa were also found. The macroconidium measured 20 μ to 32 μ x 2 μ to 4.5 μ in dimension (average 30.2 μ x 3.0 μ). The ellipsoidal to round and unicellular chlamydospores were produced in chains. They were also intercalary. The chlamydospores measured 6 μ to 9 μ in diameter (average 7 μ). The microconidia were 2 μ to 3.5 μ x 5 μ to 10 μ in dimensions. The characters of the fungus, shape, size, and measurements of the conidia and chlamydospores closely resemble those of *Fusarium oxysporum* sensu Synder and Hansen described by Wollenweber and Reiking (1935) and Synder and Hansen (1940).

CULTURAL CHARACTERS OF THE FUNGUS

In order to study the cultural characters of the fungus it was grown in oat meal agar, potato dextrose agar, Horne's & Mitter's medium, glucose agar and yeast extract agar. The macroscopic and microscopic characters were noted at room temperature. The transfers of the fungus to all media were made on the same day from single spore culture. The examination of the culture was done on 7th, 14th, and 20th day after inoculation. The macroscopic and microscopic characters were summarized in Tables 2 & 3.

TABLE 2—*Showing the macroscopic characters of Fusarium sp. on different media at room temperature* (24–28° C.)

S. No.	Characters	Oat meal Agar	Yeast Extract Agar	Potato Dextrose	Glucose Agar	Horne's and Mitter's Media
1	Mycelial growth	Cottony white	White	Cottony white	Cottony white	Wooly white
2	Color of aerial mycelium	White	White	White	White	White
3	Color of the substratum	Pink	Light pink	Dirty pink	Light pink	White
4	Odor	No	No	No	No	No
5	Sporodochia	Light pink color	Light pink color	Flesh colored	Pink	Cream colored
6	Pionnotes	None	None	None	None	None
7	Scelerotia		None	None	None	None

TABLE 3.—*Showing the dimensions of microconidia, macroconidia, and chlamydospores of Fusarium sp. in different media at room temperature* (24–28° C.)

S. No.	Media	Microconidia	Macroconidia	Chlamydospores
1	Oat meal agar	2 μ to 3.5 μ × 5 μ to 10 μ	20 μ to 32 μ × 2 μ to 4 μ	6 μ to 9 μ
2	Yeast extract agar	3 μ to 3.5 μ × 6.5 μ to 11 μ	22 μ to 35 μ × 3 μ to 8.5 μ	7 μ to 10 μ
3	Potato dextrose agar	2.5 μ to 4.8 μ × 6 μ to 12 μ	21 μ to 35 μ × 2.5 μ to 5 μ	6 μ to 10 μ
4	Glucose agar	2 μ to 3.5 μ × 6 μ to 9 μ	20 μ to 32 μ × 2 μ to 5 μ	6 μ to 10 μ
5	Horne's & Mitter's Media	2 μ to 3.5 μ × 7 μ to 8 μ	21 μ to 35 μ × 2 μ to 6 μ	6 μ to 10 μ
6	Host tissue	2 μ to 4 μ × 6 μ to 8 μ	22 μ to 30 μ × 4 μ to 7 μ	Not observed

SUMMARY

The occurrence and the symptoms of wilt disease of *Cuminum cyminum* L. (commonly known as "Jeera" in Hindustani) have been described in detail from Ajmer State where it is taking an epiphytotic form.

The pathogen has been isolated from the roots of the diseased plants and identified as *Fusarium oxysporum* sensu Synder and Hansen.

The morphology of the fungus has been described in detail and the cultural characters (both macroscopic and microscopic) of the fungus have been noted on different media.

The disease has been experimentally produced by growing the healthy seeds in the soil inoculated with the pathogen.

ACKNOWLEDGMENT

We are grateful to Dr. W. L. Gordon for the identification of the fungus, and to Dr. S. P. Wiltshire for help. Our thanks are also due to Prof. B. Tiagi for Laboratory facilities.

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*Original not seen.

Notes on the Pileate Hydnums. IV.

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The present miscellaneous notes represent gleanings and incidental studies made during 1957.

A few Bolivian hydnums

On a collecting trip in the Amazonas and Yungas forests of Brazil and Bolivia in the early part of 1956, Rolf Singer obtained a few stipitate hydnums from the latter country. All are of general interest while some are of particular interest to us because of their distribution.

Hydnodon thelephorus (Lév.) Banker

Five collections were made from three localities between early February and April. The altitude was recorded for only one specimen—1400 meters. The others were probably from a much lower altitude. Coker and Beers (3, p. 83) record the spores as "coral pink (good print)" of Ridgway in deposit and "distinctly tuberculate". Singer recorded the spores as "pink", or 4D10 of Maerz and Paul. This color, much deeper than Coral Pink, can not be matched in Ridgway, as it appears to be between Vinaceous Rufous and Dragons-Blood Red. Under the microscope the spores are hyaline and minutely echinulate to minutely tuberculate.

Hydnum atroviride Morgan

Three collections were made in February from locations at altitudes of 1900 to 2000 meters. This species is of rare occurrence in the eastern United States from Massachusetts to Florida (6, No. 65, p. 1083, Notes 1004 and 1006). As far as we know, these Bolivian collections are the second ones made outside of the United States, as Lloyd also reported this species from Japan (5, Letter 68, p. 8, Note 716)—in both cases as Peck's species *Hydnum Blackfordae.*

Singer's collections agree very closely with North American specimens except for minor variations. The surface of the pileus is hardly felted as usually described but is matted-tomentose or coactate, or even glabrous. The color dried is dull olive-green or greenish-blackish, except the base of the stipe, which is whitish-tomentose or velutinous. Since the specimens are all small, the spines are not particularly long and stout, as they are usually described. Whereas in general only one species has been accepted here, one wonders nevertheless about the two manifestations—one, Morgan's original *atroviride*, with spines not particularly rugged, and the other, Peck's *Blackfordae* now included in *atroviride*, as originally suggested by Lloyd (6, No. 65, p. 1083, Note 1006), with conspicuously long and thick spines (*cf.* Coker and Beers, 3, pl. 33).

A noticeable detail at the beginning of the examination of these specimens was Singer's characterization of the sporeprint of one of the

collections (others not given) as "fuscous", with no precise color equivalents. Coker and Beers (3, p. 53) give the spores in deposit as "dark buffy brown with a tint of fawn". Banker (1, p. 148) describes the spores of *atroviride* as dark fuscous or olivaceous, and Peck (9, p. 218) gives the spores of his *Blackfordae* as brown. The only one who says anything about the color under the microscope is Lloyd (6, No. 65, p. 1083, Note 1006), who states that they are "very pale if not hyaline". We found them to be a very pale brown to dark brown under the microscope.

We also found on the spines in various abundance—sometimes none at all after protracted search, sometimes in great abundance in clusters—hyaline cystidia or cystidium-like bodies, long-clavate or vesciculose, hyaline, 25–32 x 5–10 μ.

Singer stated in his notes that the flesh of his fresh collections turned green in KOH. By microscopic examination, we found that the dried spines crushed in KOH became a bright green in places.

Hydnum villipes

Another of Singer's collections apparently represents this species. The original collection, sent by Rick from Brazil, was described briefly by Lloyd and later more completely by Bresadola (2, pp. 41–42). It is obviously an *Auriscalpium*—**A. villipes** (Lloyd) comb. nov. (*Hydnum villipes* Lloyd—5, No. 56, pp. 801–802, fig. 1243).

A new species

A collection of very tiny specimens appears to be referable to an undescribed species. It differs from several species that appear to be nearest to it—*Hydnum petaloides* Fr., *H. luteolum* Fr., and *H. pygmaeum* Lloyd—in color, surface characters and spores, if not in habit.

Steccherinum minutissimum sp. nov.

Carpophoro minutissimo, 8–10 mm. alto, stipitato-petaloideo-erecto cum pileo laterali, horizontali, 3–4 mm. lato, glabro, dilute brunneo. Hymenophoro non decurrenti sed abrupte terminato, spinulis densis, pallide griseo-brunneis. Stipite inaequali, aspero, subgalbro, dilute brunneo, obscure brunneo vel nigridio-brunneo, 6–8 mm. longo, 1 mm. lato. Sporis in cumulis albis (?), ellipticis vel oblongis, levibus, 2.9–4 x 1.5–1.7 μ, plerumque 3.3 x 1.5–1.6 μ.

In ligno putridissimo. Bolivia.

Carpophore tiny, up to 10 mm. tall, stipitate-petaloid-erect, with pileus lateral, horizontal and 3–4 mm. broad. Surface of pilear portion glabrous, minutely puberulent under a binocular microscope, light brown. Flesh very thin. Hymenophore not decurrent but ending rather definitely on the stipe; spines crowded, simple to branching-coralloid, acute, pale grayish-brown, up to 0.35 mm. long. Stipe with basal portion perhaps enlarged, uneven and roughened, minutely puberulent under a binocular microscope, dark brown to blackish-brown, becoming lighter brown upward, the upper portion expanded into the pileus, dorsally indeterminate and like the pileus in color and surface, ventrally flattened and wrinkled and light brown, up to 8

mm. long, about 1 mm. thick in the middle. Spores apparently white in deposit, elliptical or oblong, with a few elongate-lacrymiform, smooth, hyaline, 2.9–4 x 1.5–1.7 μ, the great majority 3.3 x 1.5–1.6 μ.

On very rotten wood. Carmen Pampa, Prov. Nor-Yungas, Dpto. LaPaz, Bolivia. Type—WHS 3147.

PHELLODON MELALEUCUS

In this country, there has been some difference of opinion concerning the species of *Phellodon* with pileic surface colored from whitish to grayish, mouse-colored, the darker browns, or even black, and especially with the substance of the lower part of the pileus and of the stipe bluish-black or black.

In 1897 (8, p. 110), Peck described what is now *Phellodon alboniger* (Pk.) Banker as distinct from *P. niger* (Fr. ex Fr.) Karst., well-marked by certain characters, especially of the context. Banker (1, pp. 165–168) accepted both species, and Coker throughout his studies considered *P. alboniger* to be a distinct species but did not include *P. niger* as occurring in the United States (3, pp. 21–23).

Lloyd first compared a Massachusetts specimen with Kew material and confirmed its identity with *Hydnum nigrum* (4, Letter 45, p. 6, Note 70). Later, upon seeing a specimen of *H. nigrum* from Switzerland, he made the remark—"Certainly the same as has passed in American tradition as Hydnum albo-nigrum, a better name for it, for Hydnum nigrum is not near as black as Hydnum melaleucum, nor as black as it is painted" (7, p. 1166, Note 1128).

Near Elgin Road, County L'Islet, Province of Quebec, Harry Jackson and the senior author twice found a black *Phellodon* in a grassy path near balsam fir, spruce, arbor vitae, and tamarack. When fresh, the margin of the pileus was white for 3–4 mm. and the remainder Deep Slaty Brown, Dull Violet Black, Dull Purplish Black or Aniline Black (R). The surface was more or less scrupose and sublamellate in the center, more or less zonate near the margin, radiately rugulose to radiately fibrillose, glabrous to somewhat fibrillose-striate or distinctly tomentose in places. The substance was not noticeably duplex although slightly firmer at the base of the stipe, azonate or faintly zonate, concolorous with the pileus above and blackish-brown below. The odor was pleasant when fresh but quite strong of melilot when dry. The spines were pure white when fresh, pale buffish to Pinkish Buff or Light Buff when dried. The stipe was thin, without basal tomentum, and concolorous or darker.

These specimens were obviously not *P. alboniger*—carpophore too black, margin of the pileus and the spines pure white, flesh hardly duplex, stipe thin and without basal tomentum, etc. Also, they appeared not to be *P. graveolens* (Delast. *apud* Fr.) Banker—again too black without and within, spines pure white until dried, habitat coniferous woods instead of deciduous or mixed woods, less pronounced odor in both fresh and dried material. For almost identical reasons, as well as size, they were not *P. putidus* (Atk.) Banker, recorded by Coker and Beers (3, p. 25) as reported thus far only from North Carolina and Georgia, although Coker identified our collection number 2259 from New York as this species.

In view of the foregoing and in the present state of our information concerning North American species, the last choice appeared to be *P. niger*, of disputed occurrence on this continent. Here again, however, the fit did not appear to be quite satisfactory because of the surface characters especially in the center of the pileus, the colors, the thin stipe without basal tomentum in our specimens, and the size of the spores. Consequently, the search was carried farther and it was shortly decided that our species could be none other than *P. melaleucus* (Fr. ex Fr.) Karst. In fact, it appeared that the fit in the descriptions left nothing to be desired. Incidentally, it may be added that another collection under spruce and balsam fir from Friendship, Maine, was identified as this species.

It will be noted from the literature (see Coker and Beers, 3, p. 27) that there has been much disagreement as to the status of *P. melaleucus*. Banker and Coker both considered this species to be the same as *P. graveolens*. We, however, as explained above, believe *P. melaleucus* to be a distinct and readily separable species in our northern coniferous forests.

A CHANGE

Since it appears that the genus *Calodon* Quélet is not going to be acceptable, the following change is made—**Hydnellum mirabile** (Fr.) comb. nov. [*Hydnum mirabile* Fr. Monogr. Hymen. Sueciae II: 349. 1863 = *Calodon mirabilis* (Fr.) Snell *apud* Snell & Jackson. Lloydia **17**: 254. 1954].

SUMMARY

The following hydnums collected by Singer are reported from Bolivia, with appropriate discussions—*Hydnodon thelephorus* (Lév.) Banker, *Hydnum atroviride* Morgan, *Auriscalpium villipes* (Lloyd) comb. nov., and *Steccherinum minutissimum* sp. nov. *Phellodon melaleucus* (Fr. ex Fr.) Karst. is reported from the Province of Quebec and Maine. *Hydnellum mirabile* (Fr.) is a new combination.

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A Contribution Toward a Monograph of Cotylidia (Thelephoraceae)

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While identifying tropical species of *Stereum* collected by myself and others, several discordant elements in the genus have become apparent. Some of the genera delineated by Karsten, Patouillard, and others better accomodate these elements than *Stereum*. *Cotylidia* is one such genus. Karsten established this genus in 1881 based on *Cotylidia undulata* (Fr.) Karsten. Some authorities such as Lund (K. Sv. Vet. Akad. Skr. i Nat. 1932) have recognized *Cotylidia;* others, for the most part, have either ignored it or refused it valid distinction.

Historically, the species treated here have been placed in *Stereum*, which includes almost any basidiomycete with a relatively smooth hymenium, hyaline, smooth spores, varying in habit from effuso-reflexed to stipitate, but including a few resupinate forms. Previous to the elevation of *Stereum* to generic rank, *Cotylidia* species were placed by Persoon (Syn. Meth. Fung. 1801) and Fries (Syst. Myc. 1821), among others, in *Thelephora*. Berkeley and Curtis, prolific commentators on these and related species, followed the Friesian concept. However, Massee (1890), Lloyd (1913), and Burt (1920) transferred them to *Stereum;* a trend exemplified by Burt's *Thelephoraceae of North America*. Patouillard (1901) recognized the artificiality of *Stereum* and *Thelephora* and placed certain of their species in *Podoscypha*, others in his genus *Thelephora*. Bourdot and Galzin (1927) followed Patouillard in their treatment of these species as they occur in France. Many of these transferred species were the ones here grouped in *Cotylidia*. Patouillard's *Thelephora* is alien to modern concepts of this genus, and the *Cotylidia* species form a heterogeneous element in the otherwise homogeneous *Podoscypha*.

Paul Lentz (1955) is the most recent worker to recognize the validity of *Cotylidia*. He utilized recent techniques in basidiomycete taxonomy advocated by Rogers (1943, 1944), Talbot (1954), Corner (1950), Cunningham (1953), Pinto-Lopes (1952), and others. According to Lentz *Cotylidia* is a great deal simpler in construction than the majority of Stereums and their relatives. Three species: *C. undulata* (Fr.) Karsten, the type, *C. diaphana* (Schw.) Lentz, and *C. aculeata* (Berk. et Curt.) Lentz, are grouped in this genus. Lentz approached *Cotylidia* solely in regard to temperate species. The present treatment is based on tropical and subtropical material which strengthens Lentz's concept but does entail some nomenclatorial changes and the exclusion of *C.aculeata*.

In addition to specimens which I have examined, Lentz's and Burt's lists have been used in compiling the distribution of each species.

[1]The collection of specimens in Jamaica was made possible by Grant No. 2196 from the Penrose Fund of the American Philosophical Society.

COTYLIDIA Karst., Rev. Mycol. **3**(9): 22. 1881.

Thelephora Ehrh. ex Fr., Syst. Mycol. **1:** 428. 1821. *pro parte sed non typica.*
Stereum Hill ex S. F. Gray, Nat. Arr. Brit. Pl. 652. 1821. *pro parte sed non typica.*
Podoscypha Pat., Essai Tax. 70. 1900. *pro parte sed non typica.*
Bresadolina Brinkm., Ann. Mycol. **7:** 289. 1909.

Basidiocarps erect, on soil or wood, sessile to stipitate, bibulous through papery-coriaceous, often white or pallid when fresh, drying yellow through cinnamon to brown; pileus varying from wedge-shaped, spathulate, flabelliform to infundibuliform, in one species dissected, margin even through fimbriate to pectinate, upper surface lineate-striate because of loose hyphae, lower surface concolorous with upper, smooth, slightly folded, or, in one species, toothed.

In section the pileus is composed of two zones or areas: the context and the hymenium; context well-developed, composed of longitudinally-parallel hyphae with thin or slightly thickened walls, may be inflated slightly, lacking clamp-connections but possessing septa, without any well-developed cuticle and bounded at its lower surface by the hymenium; hymenium of basidioles, cylindrical-clavate basidia with four sterigmata, and, in some species, long, cylindrical, cystidia projecting well above the hymenial surface, these may be septate or not, slightly incrusted or not, and may have swollen tips; spores smooth and hyaline.

TYPE SPECIES: *Cantharellus undulatus* Fr., Syst. Mycol. 1: 321. 1821.

In the present work five species are recognized as valid. A glance at the synonymy of several species will show a rather large reduction of previously recognized species. This attrition of species is justified when one gives close attention to microscopic detail. The variability in gross morphology and habit is often considerable and only by microscopic analysis can order be brought to the group. In such an analysis the genus seems to fall naturally into five groups or species. Some of these species are based on an embarrassingly small number of specimens. Additional collections may well cause some realinement. Further investigation into other less well-known species of *Stereum* may also add other species to *Cotylidia*.

In comparing *Cotylidia* with *Stereum* and its other segregates, the extremely simple plan of construction in *Cotylidia* is striking. *Stereum*, as typified by *Stereum hirsutum*, *S. versicolor*, *S. striatum* group, but not *S. albo-badium* and its relatives, resembles *Cotylidia* only in its lack of clamp-connections. The presence of a cuticle, the thicker walled hyphae, and the numerous specialized hymenial structures, as well as habit in *Stereum*, sharply separate it from *Cotylidia*. *Cymatoderma*, with its clamp-connections, cuticle, and hyphal structure, is very distinct from *Cotylidia*. The clamp-connections and loosely interwoven hyphae of *Laxitextum* show little relationship to the anatomy of *Cotylidia*.

KEY TO SPECIES

1. Cylindrical cystidia projecting prominently from the hymenium, easily seen in thin sections of the pileus.
   2. Basidiocarp brownish, small; cystidia projecting from the hymenium up to 70 μ; spores 3–5 $\times$ 2–3 μ ..... *C. undulata*
   2. Basidiocarps yellowish when dry, large; cystidia projecting from the hymenium up to 210 μ; spores 6–10 $\times$ 3–5 μ ..... *C. aurantiaca*

1. Cystidia absent.
   3. Basidiocarps rarely above 12 mm. in length; spores 4–8 × 3–5 μ.
      4. Pileus more or less greatly dissected, pectinate along the margins of the segments, often toothed on the hymenial surface..... *C. Hartmanni*
      4. Pileus usually not dissected, if so, not pectinate or toothed..... *C. cyphelloides*
   3. Basidiocarps usually longer than 12 mm. in length; spores 6–13 × 5–7 μ..... *C. decolorans*

COTYLIDIA UNDULATA (Fr.) Karst., Rev. Mycol. **3**(9): 22. 1881.

Lentz (p. 13) lists the extensive synonymy of this variable species and his description is more than sufficient for a correct diagnosis. I have nothing to add.

DISTRIBUTION: Cuba, United States, Europe.

Illustrations: Burt, pl. 2. f. 10 (as *S. exigium*). 11 (as *S. tenerrimum*); Lentz, pl. 1, fig. C, D; pl. 8, fig. B, pl. 12, f. B, pl. 13, f. D; Lloyd, f. 535 (as *S. undulatum*).

Cotylidia aurantiaca (Pers.) comb. nov.

Thelephora aurantiaca Pers., in Gaud. Voy. Uranié Bot. 176. 1821 (non *Thelephora aurantiaca* (Sow.) Berk., in Smith, Engl. Fl. **5**(2): 169. 1836); *Podoscypha aurantiaca* (Pers.) Pat., in Duss, Fl. Crypt. Antilles Fr. 230. 1904.
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Thelephora spectabilis Lév., Ann. Sci. Nat. Hist. Bot. III. **2:** 206. 1844.
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Thelephora sericella Berk. et Curt., Linn. Soc. Bot. Jour. **10:** 328. 1868.
Thelephora affinis Berk. et Curt., Linn. Soc. Bot. Jour. **10:** 329. 1868.
Thelephora diaphana Schw., in Berk. et Curt., Acad. Nat. Sci. Phila. Jour. **2:** 278. 1853; *Stereum diaphanum* (Schw.) Cke., in Sacc., Syll. Fung. **6:** 558. 1888; *Cotylidia diaphana* (Schw.) Lentz, Agric. Monog. 24: 12. 1955.
Thelephora Sullivantii Mont., Syll. Crypt. 176. 1856.
Thelephora Willeyi G. W. Clint, in Peck, N. Y. State Mus. Ann. Rept. **26:** 71. 1874; *Stereum Willeyi* (G. W. Clint) Burt ex House, N. Y. State Mus. Bull. 219–220: 237. 1920.
An *Stereum xanthellum* Cke., Grev. **9:** 12. 1880?

Basidiocarps erect, membraneous, soft, separate, gregarious to crowded, often brittle, yellowish when dry, 4–40 × 5–50 mm; pileus wedge-shaped, spathulate, flabelliform to infundibuliform, splitting occasionally, upper surface lineate-striate, more or less tomentose because of loose hyphae, lower surface concolorous, smooth, an occasional specimen approaches the *C. Hartmanni* condition described below; stipe cylindrical or somewhat flattened, especially at juncture of stipe and pileus, whitish or yellowish tomentum at base, 4–15 × 0.5–4 mm.

Pileus in section 300–400 μ; hyphae 3–7 μ in diam.; cystidia long, cylindrical, occasionally slightly incrusted, often with swollen tips, may be septate, emerging from the hymenium up to 210 μ, 9–15 μ in diam., young, clavate, or cylindrical cystidia may often be found imbedded in the hymenium; basidia 30–37 × 4–7 μ, sterigmata 3–5 μ long; spores 5–8 × 3–5 μ; on wood or soil, most often on soil.

SPECIMENS EXAMINED: In addition to the specimens previously cited (Bull. Torr. Bot. Club *81:* 426, 429. 1954), the following have been examined: *Jamaica:* D. A. Powell *386*, ALW *478*, *497*, *526*,

575, 675 (NO); *Santo Domingo:* TYPE of *Thelephora spectabilis* Lév. (PC); *Cuba:* C. Wright 1857 as *S. quisquilliare* (B. & C.) Lloyd (NY); *United States:* Sullivant 74 probable TYPE of *S. Sullivantii* Mont. (PC), *Ohio*, Gnadenhutte, TYPE of *Thelephora diaphana* Schw. (PH), a second fruit body is present in the type collection bearing nodulose hyphae and small echinulate spores.

DISTRIBUTION: Venezuela, Trinidad, St. Kitts, Santo Domingo, Jamaica, Puerto Rico, Cuba, Bahamas, Panamá, United States, Europe, China.

Illustrations: Burt, pl. 2, f. 8, 9, text f. 3 (as *S. diaphanum*), pl. 2, f. 6 (as *S. quisquiliare*), pl. 6, f. 7, text f. 2 (as *S. aurantiacum*); Lloyd, f. 534 (as *S. diaphanum*), f. 536 (as *S. Sowerbeyi*), f. 538 (as *S. aurantiacum*), f. 557 (as *S. quisquiliare*); Montagne in Ramon de la Sagra, Fl. Cub. *4:* 228; Persoon, Ic. et Descr. Fungi I: pl. 1 f. 3; Sowerbey, Col. Fig. Engl. Fung. pl. 155.

Cotylidia decolorans (Berk. et Curt.) comb. nov.

Stereum decolorans Berk. et Curt., Linn. Soc. Bot. Jour. **10:** 328. 1868.
Stereum Burtianum Peck, N. Y. State Mus. Bull. **75:** 21. 1904.

Basidiocarps erect, stipitate to subsessile, often arising from a common site, gregarious to caespitose, 15–40 mm. long, 6–30 mm. wide; pileus papery-coriaceous, flabelliform to infundibuliform, yellowish to cinnamon, often confluent, upper surface striate, faintly tomentose, lower surface smooth, concolorous; stipe, 5–10 × 0.5–1 mm. which arises from a mycelial pad which is separate or common to a group of basidiocarps.

Hyphae 3–10 μ in diam.; basidia 44–45 × 7–8 μ, sterigmata 3–4 μ long; spores 6–8(–13) × 5–7 μ; on soil or wood.

SPECIMENS EXAMINED: Cuba: C. Wright *234, 248*, TYPE of *Stereum decolorans* B. & C. (FH–C); New York: C. H. Peck, TYPE of *Stereum Burtianum* Pk. (NYS); Japan: Gendai, A. Yashuda (NY).

DISTRIBUTION: Trinidad, Jamaica, Cuba, eastern coast of the United States, Japan.

Illustrations: Burt, pl. 2, f. 5 (as *S. Burtianum*), pl. 3, f. 234 (as *S. decolorans*); Lloyd, f. 537 (as *S. Burtianum*); Peck, N. Y. State Mus. Bul. 75: 21. pl. O, f. 30–34. 1904.

Cotylidia Hartmanni (Mont.) comb. nov.

Thelephora Hartmanni Mont., Ann. Sci. Nat. Bot. II. **20:** 366. 1843; *Stereum Hartmanni* (Mont.) Lloyd, Myc. Writ. **4.** Stip. Stereums 34. 1913.
Thelephora dissecta Lév., Ann. Sci. Nat. 3. ser. V. 146. 1846.

Basidiocarps erect, separate, papery-coriaceous, reddish-yellow or yellow when dry, 6–12 mm. long; pileus spathulate to flabelliform but this is not distinct because of the deeply dissected lobes, margins and apices of segments fimbriate to pectinate, with teeth-like projections on hymenial surface; stipe very short or absent.

Hyphae 3–7 μ in diam., some inflated up to 13 μ in diam.; basidia not seen; spores 4–8 × 3–5 μ; on woody or herbaceous stems according to Burt.

SPECIMENS EXAMINED: Guadeloupe: M. Beaupertius, *1839*, as

Thelephora dissecta Lév. (PC); Puerto Rico: Wilson *313* (NY); Carolina: TYPE of *Thelephora Hartmanni* Mont. (PC).

DISTRIBUTION: Bolivia, Guadeloupe, St. Kitts, Puerto Rico, Carolinas.

Illustrations: Burt, pl. 3, f. 21 (as *S. Hartmanni*); Lloyd, f. 553 (as *S. Hartmanni*).

Cotylidia cyphelloides (Berk. et Curt.) comb. nov.

Stereum cyphelloides Berk. et Curt., Linn. Soc. Bot. Jour. **10:** 331. 1868.

Basidiocarps erect, separate, gregarious to crowded, bibulous, 2–8 × 1–6 mm.; pileus flabelliform to spathulate, longitudinally fibrillose, white when fresh, drying yellow; margin entire; stipe short, concolorous, sometimes flattened.

Pileus up to 500 μ in section; hyphae 2–5 μ diam.; basidia 22–28 × 4–5 μ, sterigmata 3–5 μ long; spores 4–6 × 3–4 μ, nonguttulate, or rarely so; on soil, often among mosses and liverworts.

SPECIMENS EXAMINED: In addition to those cited in the Bull. Torrey Bot. Club 81: 426. 1954, one specimen from Jamaica (Maggoty Falls, ALW *413*) has been examined (NO). It was white when collected.

DISTRIBUTION: Colombia, Jamaica, Cuba, Puerto Rico.

Illustrations: Burt pl. 3, f. 20 (as *S. cyphelloides*); Talbot Bothalia 6: 334, f. 5 (as *S. cyphelloides*) 1954.

SPECIES EXCLUDENDAE

COTYLIDIA ACULEATA (Berk. et Curt.) Lentz, Agric. Monog. 24: 11. 1955.

From an examination of the type (South Carolina: Santee Canal, Swamp, Ravenel *764*, June 1848, FH–C) this species differs radically from *Cotylidia* as delimited here. It is actually *Podoscypha elegans* (B. & C.) Pat.

SPECIES ENQUIRENDAE

STEREUM FLORIFORME Bres., Ann. Mycol. **18:** 44. 1920.

There were no specimens available for study. According to Lloyd's photograph and description, this species could be *C. decolorans* or *C. pallida*. The spore size is near *C. pallida* but Bresadola does not mention cystidia in his description.

CLADODERRIS FORMOSA Lév., Ann. Sci. Nat. 3. sér. **3:** 21. 1845.

A small specimen in Planta Javanica a cl. Zollingers lecta from Paris (No. 2055) of this species has been examined. The hyphae are *Cotylidia* type with pileus lacking a cuticle. In section the pileus is 825 μ thick. Gloeocystidia may have been present but this point was difficult to determine. Spores measuring 5 × 4 μ were found but I was unable to prove that they belonged to *C. formosa*. From its general appearance this species is a *Cotylidia* but on the basis of such a small collection I am unwilling to include it within the genus.

STEREUM PALLIDUM (Pers.) Lloyd, Myc. Writ. 4. Stip. Stereums 31. 1913; Burt, Ann. Mo. Bot. Gard. 7: 104. 1920.

According to the description of this species given by Burt it strongly resembles *C. aurantiaca*. The setulose hymenium and other details are strikingly similar. Burt, however, did not see type or authentic material but relied upon specimens sent to him from Europe by Bresadola purporting to be *Stereum pallidum*. Lloyd states that he failed to find the setulose hymenium described by Persoon. Since the deposition of species within this genus is dependent upon the presence or absence of cystidia it was necessary to examine authentic material of Persoon's species.

Two specimens from the Persoon herbarium were obtained on loan from the Rijksherbarium and examined. One (L. 1759, No. 6), labelled *Thelephora pallida* in Persoon's hand, is the probable type. Unfortunately this specimen has its hymenium overgrown with a foreign fungus bearing relatively thick-walled spores with flattened ends and spiny walls. These spores measure 5–7 × 4–5 μ. It was impossible to discern the presence of cystidia. Several hyaline spores (partially collapsed) which may belong to Persoon's species were found. They were apiculate, thin-walled, 6–7 × 3–4 μ. Many of the hyphae were shriveled and failed to recover in KOH preparations. However, it was possible to determine that they are thin-walled, 3–5 μ in diam., and do not possess clamp-connections. There seems little doubt that it is a *Cotylidia*, but the species must remain in doubt.

The second specimen, labelled *Helvella pannosa* in Swartz's hand, bears no relationship to *Cotylidia*. Instead, it is more closely related to the *Stereum frustulatum* group of fungi.

The names generally associated with *Stereum pallidum* (Pers.) Lloyd are: *Craterella pallida* Pers., *Thelephora pallida* Pers., *Helvella pannosa* Sow., *Thelephora pannosa* Sow. ex Fr., *T. pannosa* var. *pallida* (Pers.) Fr., *T. Sowerbeyi* Berk., *Stereum Sowerbeyi* (Berk.) Massee, *Bresadolina pallida* (Pers.) Brinkm., *Thelephora multizonata* Berk. & Br., *T. intybacea* Quél., and *T. albocitrina* Quél. Obviously at least two fungi are involved here, *Thelephora pallida* Pers. and *T. pannosa* Sow. ex Fr. The type of *T. pannosa* is unavailable to me and the relationship of this species to *T. pallida* is not known. According to Burt, Berkeley segregated *T. Sowerbeyi* and *T. multizonata* from Sowerbey's species dropping the name *pannosa* (= *T. Sowerbeyi* fide Burt). Lloyd believes Quélet described a specimen of *T. pannosa* as *T. intybacea* and later transferred it to *T. albocitrina*.

Bourdot and Galzin (1927) make no mention of cystidia in *Thelephora pallida* but the hyphae are *Cotylidia*-like. Rea (1922) describes cystidia for the species. Bourdot and Galzin's (p. 82) and Rea's (p. 662) descriptions of *T. multizonata* give no indication of whether or not it is a *Cotylidia*. *T. intybacea*, as described by Bourdot and Galzin, is a true *Stereum*. Rea's *T. Sowerbeyi* (p. 661) is strongly reminiscent of *Cotylidia aurantiaca*.

I wish to acknowledge with thanks the courteous consideration of the following curators of mycological collections. With unfailing cooperation they have supplied me with types and authentic specimens whenever possible. Drs. R. A. Maas Geesteranus and M. A. Donk of

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New Genera of Fungi, IX.
The Probable Ancestor of the Strophariaceae: Weraroa gen. nov.

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During a revision of some secotiaceous genera, I came across a specimen of *Secotium novaezelandiae* Cunningham (Proc. Linn. Soc. New South Wales 49: 107. 1924) which, although typically gastroid in appearance and development, is as close to the Strophariaceae as any secotiaceous species could be expected to be, and as close as *Brauniella* Rick in Sing. is to the Amanitaceae (*Volvariella*) or *Thaxterogaster* Sing. to the Cortinariaceae (*Cortinarius*). The specimen is a topotype and authentic (from the type locality, Weraroa, and determined by Cunningham, preserved at the University Herbarium, University of Michigan, Ann Arbor, Mich.) and showed all the visible characters of the species as described by Cunningham[1] on p. 81. It was collected by J. C. Neill and G. H. Cunningham, February 5, 1923 at Weraroa, Wellington, N. Z., no. 1098 (MICH).

The spores were found to be typical for *Psilocybe* in structure, shape and color, sepia in KOH, smooth, with a distinct germ pore, with thick complex wall, consisting of a smooth pale melleous to hyaline exosporium, a russet fulvous thin episporium, and a thick (probably double) endosporium which is light olive melleous, with a short and often oblique hilar appendage, without suprahilar applanation or depression but spores at times slightly less convex on the inner side than on the outer (but many spores not noticeably different in front view from profile outline), 12–14–(17) × (6)–7–8.5–(10.8) μ; basidia hyaline, variable in shape and assuming all those shapes known to occur in *Psilocybe* such as subcylindric to clavate or bi-ventricose (with a constriction somewhat above the center), (14)–18–28 × 5.5–7.7 μ, with four (very rarely fewer) spinose straight acute sterigmata; true pleurocystidia, particularly chrysocystidia were not observed, but there are at least at the edges of the tramal plates toward the hollow below the gleba (hymenophore) of the overmature specimens (i.e., after the spore formation has virtually been completed), numerous cystidioles which are similar to the cheilocystidia of many strophariaceous agarics, ampullaceous, about 22 × 7.5 μ, apex cylindrical 2.5–2.7 μ in diameter, hyaline or with a melleous globose incrustation at apex; trama of the hymenophoral plates not or not strongly gelatinized, melleous-hyaline, regularly arranged (but hyphae not strictly parallel with each other), hyphal walls up to 1.2 μ thick; hypodermium of the peridium (pileus)

[1]**Cunningham, G. H.** 1942. The Gastromycetes of Australia and New Zealand. Dunedin, N. Z., pp. 1–236, 37 pls.

melleous to light ochraceous-fulvous, consisting of a cutis formed by parallel to subparallel hyphae, some rather strongly swollen or ventricose, reaching 22 μ in diameter, walls up to 1.3 μ thick but not incrusted by pigment; epicutis above hypodermium gelatinized and basically a cutis, i.e., quite like a pellicle of a viscid *Psilocybe*, hyaline loosely arranged, consisting of hyaline thin-filamentous (1–1.3 μ) hyphae; all hyphae with clamp connections, those of the internal tissue (trama of peridium and stipe-columella) melleous-hyaline.

Obviously, lacking chrysocystidia and a subcellular hypodermium, with a not perfectly parallel-hyphous hymenophoral trama, this species would be closer to *Psilocybe* than to any other genus of the Strophariodeae, the spore color excluding the Pholiotoideae. Checking on the macroscopical description of the fresh specimens, I was particularly surprised to find that the exterior of the peridium is indicated as "changing to pallid green, often bluish green" and the "stem" being pallid french grey or bluish green. This character is characteristic for a number of Gastromycetes and Agaricales, but as far as species with the spore type of *Secotium novaezelandiae* are concerned, it is matched only by the representatives of the genus *Psilocybe*, section *Caerulescentes* Sing., recently monographed by Singer & Smith.[2]

This addition to the already impressive list of links between Gastromycetes and Agaricales tends to fill in a blank where, for the understanding of Basidiomycete phylogeny, an additional link was particularly desirable. If we understand gastroid conditions of agarics as atavistic possibilities realized under conditions of deficient nutrition, humidity, light, or whatever, or even as the consequence of a minor mutation leading to strains capable to form both agaricoid and gastroid carpophores, we shall have to postulate the existence of purely gastroid ancestors, at least in all agaric groups were gastroid conditions have been observed either in nature or in the laboratory. The latter has been the case in a species of *Psilocybe* grown at Michigan by K. H. McKnight (see Mycologia **45:** 793–794. 1953), and it may now be assumed that *Psilocybe* (and the Strophariaceae) did have secotiaceous ancestors.

This secotiaceous ancestor is sufficiently different from the type of the genus *Secotium* to justify the proposal of a new genus to accomodate *S. novaezelandiae* Cunningham. This genus is thus far monotypic, but it may be assumed that other species will be found to be close to it. I propose the new genus *Weraroa* Sing. gen. nov. based on *Secotium novaezelandiae* Cunningham, l.c. This species is the generic type and its diagnosis coincides to a large degree with the diagnosis of the new genus. The new combination **Weraroa novaezelandiae** (Cunningham) Sing. (*Secotium novaezelandiae* Cunningham, l.c.) is proposed.

Weraroa gen. nov.

Familiae Secotiacearum strato peridiali externo gelatinisato, ex

[2]**Singer, R.** and **A. H. Smith.** 1958. Mycological investigations on teonanácatl, the Mexican hallucinogenic mushroom, part II. A taxonomic monograph of *Psilocybe*, sect. *Caerulescentes*. Mycologia **50:** 1958.

hyphis filamentosis efformato; gleba loculata vel paulum sublamellosa, demum partim peridio haud obtecta; stipite columellaque percurrente praesentibus; velo partiali praesente. Sporis magnis, poro germinativo bene evoluto instructis, colore suo eas Strophariodearum in mentem revocantibus, levibus, membrana complexa praeditis; hyphis tramatis hymenophoralis regulariter dispositis, omnibus fibulatis. In superficie terrae humosae vel ligni emortui fructificans. Species typica *W. novaezelandiae* (Cunn.) Sing.